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INCREASING THE RESOLUTION OF SIMULATED COMBAT TRAUMA INJURIES IN A HIGH LEVEL ARCHITECTURE (HLA) ENVIRONMENT

by

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ABSTRACT

This research develops a technique that leverages Operational Requirements-based Casualty Assessment (ORCA) generated patient conditions for use in the Combat Trauma Patient Simulation (CTPS). The research paves the way for enhancing the resolution of combat trauma injuries in a High Level Architecture (HLA) environment.

ORCA is U.S. Government-owned software developed by the Crew Casualty Working Group (CCWG). The ORCA methodology calls for the initial creation of a "medical casualty" in order to determine the affects on the body's ability to perform certain military tasks. The Alpha + version upon which this paper is based had working modules for only five of seven planned injury-inducing insult types. These are Penetrators (fragments), Blast overpressure, Thermal fluence, Toxic gases (military agents), and Directed Energy.

The CTPS research team is prototyping and evaluating a training and analysis HLA federation that realistically simulates the emergency medical treatment process from the time of injury through initial treatment at a field hospital. The goals of the project are to decrease the deaths due to combat wounds by having better trained medical staffs and to provide a mechanism for analysis and for test and evaluation (T&E) of issues in casualty medical treatment. In addition to ORCA, a central component of this

system is a physical simulation of a casualty (an instrumented mannequin), the Human Patient Simulator (HPS).

Products of this research include a methodology and techniques for generating ORCA injuries and storing the injury profiles offline in a database. This database can later be read by CTPS to enhance the injury data available on a given casualty. Future work can automate this process.

This research also discusses a prototype injury Simulation Object Model (SOM), that objectifies the ORCA output data. Additionally, a prototype Federation Object Model (FOM) is presented. Researchers plan to use this FOM in future phases of the CTPS program. Finally, the research highlights the relevance of such object models to the possible addition of future, more visually oriented, components to the CTPS.

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AAR	After Action Review
AIS	Abbreviated Injury Scale
ARL	Army Research Laboratory
BV	Blood Vessel
CCWG	Crew Casualty Working Group
CTPS	Combat Trauma Patient Simulation
DEPMEDS	Deployable Medical Systems
DMSO	Defense Modeling and Simulation Office
DOD	Department of Defense
ECC	Electronic Casualty Card
FOM	Federation Object Model
GUI	Graphic User Interface
HOH	Hollow Organ – Hard
HOS	Hollow Organ – Soft
HLA	High Level Architecture
HPS	Human Patient Simulator
ISS	Injury Severity Score
IST	Institute for Simulation and Training
JMSL	Jackson Medical Scenario Library
JTCG	Joint Technical Coordinating Group
LC	Line of Contact
LCD	Liquid Crystal Display
LD	Line of Departure

MAIS	Maximum AIS
MERLIN	Medical Readiness Learning Initiative
METI	Medical Education Technologies Inc.
MILES	Multiple Integrated Laser Engagement System
OBC	ORCA Body Component
OMDT	Object Model Development Tool
ORCA	Operational Requirements-based Casualty Assessment
PATSIM	Patient Simulator
RTI	Run Time Infrastructure (pertaining to HLA)
RTI	Research Triangle Institute
SO	Soft Organ
SOM	Simulation Object Model
STRICOM	Simulation Training and Instrumentation Command
T&E	Test and Evaluation
TMC	Troop Medical Clinic
UCF	University of Central Florida
USAARL	U.S. Army Aeromedical Research Laboratory
VMT	Virtual Medical Trainer
VMET-TPS	Virtual Medical Trainer – Trauma Patient Simulator
VR	Virtual Reality

CHAPTER 1

1.1 Introduction

Current combat medic training scenarios lack realism, standardization, depth (through entire battlefield evacuation process), and an accurate playback mechanism for After Action Review (AAR) purposes. These shortcomings of the simulated medical component result in medical personnel lacking in many areas of combat casualty care (Rajput, Goldiez, & Petty, 1997). Also, the future of traditional medical training methods, such as using traumatized animals as patients, is in jeopardy (Stansfield, Shawver, & Sobel, 1998).

Although current medical training simulators may fall far behind their real world, live-tissue alternatives, there is hope for the future. This is evident in the statement by Satava and Jones (1997a), concerning medical simulations. Satava and Jones stated that cartoon-like medical simulations are likely to follow the same evolutionary path as their flight simulator counterparts. Flight simulators took approximately 40 years to reach their ultra-realistic current state.

1.2 Issues in Combat Medical Training

1.2.1 Wartime Casualty Flow

In wartime, the number of casualties may grow so quickly that all levels of care are either "pushed down" to lower levels, providing someone knows and can perform the appropriate procedures, or they are not done in a timely manner. The ability to provide continuous combat casualty care forward of the line of departure (LD)/line of contact (LC) is a considerable challenge. The pre-hospital phase of caring for combat casualties is critically important, since up to 90% of combat deaths occur before the casualty ever reaches a medical treatment facility (Sobczak & Freshour, 1997). During intense periods of fighting, it is easy to see how the patient to medic ratio may become so large that even a seasoned medic would panic, resulting in a lower quality of combat medical care and more deaths due to combat wounds.

1.2.2 Traditional Training Methods

Current training methodology focuses on live training exercises: medics either practice stabilization and wound care on animals (e.g. shooting and treating a goat) or via moulage, where live soldiers are given highly realistic "fake" wounds via special make up (Stansfield et al., 1998). Traditionally, medical combat training scenarios have either been scripted and given on paper or read aloud to a medic at the casualty site. In the case of the wounded animal, live tissue serves to enhance realism, while the instructor keeps the scenario on track with scripted inputs. In such cases, animal physiological and pathophysiological processes are often very similar to those of a human. However, varying degrees of difference in overall anatomy, coupled with the visually induced psychological aspect of knowing that the patient is non-human, produce an overall affect of decreased scenario realism. Also, over the years these methods have met with increased scrutiny by animal-rights activists.

In the case where the "patient" is another perfectly healthy individual, the trainee may be able to realistically go through the motions of patient care, such as checking for breathing and pulse, and perhaps even performing a more difficult procedure such as administering intravenous fluid therapy (starting an IV). Since the "patient" is healthy, the instructor must interject any abnormal parameters into the scenario, in verbal or written fashion. In some cases, a mannequin, with moulaged injuries, is used in a similar manner. The non-instrumented mannequin is used primarily for injury identification, with limited capability to perform minor procedures such as application of splints or dressings. In either case (live soldier or mannequin), written or verbal input on vital signs and other indications of internal injury must be interjected into the scenario and the medic does not get to practice realistic wound care. This type of input into a scenario, particularly verbal, has inherent problems. Variations in simulated battlefield sounds, instructor's voice (pitch, volume, and accent), and instructor or trainee's ability to read all impact on the overall realism and standardization of the training session. Additionally, unless the training sessions are videotaped, there is no detailed, unbiased account for after action purposes.

The military's use of the Electronic Casualty Card (ECC), which interacts with the MILES II System (Tinawi & Escobedo, 1996), attempts to overcome some of the lack of realism inherent to these training methods by allowing medic interaction with a live simulation casualty via a medical treatment gun. When utilizing the MILES II System, each soldier participating in a live simulation wears a sensor-laden harness. Weapons are fitted with a laser device for transmitting weapon-specific information. The MILES II sensors may be "hit" by these weapons, simulating a battlefield injury. Once a MILES injury is sustained, the severity of the wound and the prognosis for the soldier's near term condition are displayed on the LCD display on the soldier's chest. A medic is then able to "shoot" the casualties harness with a Medical Control Device. "Shooting" enables the ECC software to initialize a treatment routine, whereby the medic can select the most appropriate treatment for the injury received. This technique trains the combat medic in only one area, identification of proper treatment, with no opportunity for realistically treating the patient.

1.3 Do Medical Simulations Work?

1.3.1 Background

Kubala and Warnick (1979) found that knowing exactly what to expect in combat reduces fear and stress. Kubala and Warnick further stated, quite obviously, that training for combat should be done as realistically as possible. Soldiers should be introduced into fearful situations gradually, with proper coaching, to make sure that they make the correct responses when frightened in a combat situation. The recommended combat training program maximizes realism and thoroughly trains critical tasks to the extent that they become almost automatic, regardless of how severe conditions may become. This type of training brings about a strong sense of situational confidence. There are key training conditions that form the basis for a confidence-strengthening training program. Kubala and Warnick list these as high degrees of fidelity for job performance execution and performance feedback, coupled with repeated execution of the tasks under realistic conditions. These training conditions apply to all soldiers, from tank crewmen to medics.

There are a number of reasons why simulations can provide the conditions necessary for successful, confidence-strengthening, combat training. First, current and ongoing technological advances in the computer arena mean greater fidelity. In essence, fidelity is constrained by budget and acceptability of the user interface (a technological limitation). Second, computers make wonderful elephants. They truly never forget. The standardization and after-action capabilities inherent in many simulations make them perfect "repetitious trainers". Lastly, high-fidelity standardized training simulators are very capable of replicating realistic conditions, without placing participants in harm's way.

1.3.2 Specific Case Study

Use of a simulator to train fiber-optic intubation resulted in improved performance versus traditional teaching methods (Ovassapian, Yelich, Dykes, & Golman, 1988). The study compared a graduated training program with that of a traditional teaching method. Thirty-two anesthesia trainees were randomly assigned to two groups. One group used a graduated program involving practice on a bronchoscopy teaching model (a physical simulator), followed by visual exposure to live tissue (epiglottis and vocal cords) in recovering patients, and final performance of fiberoptic nasotracheal intubation in awake sedated patients. The other group used the program involving demonstration (on a patient) of one intubation by the instructor, followed by performance of intubation (by the trainee) in awake sedated patients. Successful nasotracheal intubation was accomplished significantly more often by the trainees in the graduated program (86 out of 96 (89.6%) v. 64 out of 96 (66.5%) (P less than 0.01).

1.4 Current Use of Medical Simulations

There are a number of potential medical training devices either currently on the market or in various stages of development. Basically, these break down into two distinct areas, hardware-based and software simulation products. Hardware products allow realistic human interaction, such as by touch and feel. Software simulation products allow simulation of a patient's physiology and pharmacological, as well as treatment through a computer model, utilizing a graphical user interface.

1.4.1 Physical Simulations

There are many physical simulation products currently on the market, including the Leiden simulator (Rajput & Fang, 1998). The Leiden Anesthesia Simulator creates a training environment for anesthetists. It makes use of a standard anesthesia machine and monitoring devices. A mannequin attached to an electro-mechanical lung machine represents a simulated patient. A physiological and pharmacological model controls the patient's simulated parameters.

The Eagle Patient Simulator (Rajput & Fang, 1998) consists of a full body mannequin, operator station, interface cart housing the electronic and pneumatic drive equipment, and software describing patient physiology. Its features include thirty simulated cardiovascular, pulmonary, and metabolic events and simulated physiological reactions to 85 drugs. It also allows for scenario generation by the instructor/operator.

Another full body mannequin, the Medical Education Technologies (METI), Inc./University of Florida Human Patient Simulator (HPS) is a full scale, fully interactive, life-like simulator (Rajput et al., 1997). Clinical features include palpable pulses, self-regulating control of breathing, heart and breath sounds, electrocardiograms, pulmonary artery pressure. Physiological and pharmacological models direct simulated patient responses (both normal and pathophysiological) to drugs, mechanical ventilation, and other medical therapies. It is being utilized as part of a larger scale simulation, the Combat Trauma Patient Simulation (CTPS), discussed in greater detail later in this chapter. More detailed discussion on the inner workings of the CTPS may be found in Chapter Two.

The Special Operations Medical Training Facility at Fort Bragg, North Carolina, recently acquired a HPS. This simulator is being evaluated as a replacement for some of the live animal models, as well as an enhancement to the training program.

1.4.2 Software Models (Virtual and Constructive Simulations)

Some current medical simulations are attempting to take advantage of advances in computer graphics and visualization, by creating virtual training environments. The Virtual Medical Trainer – Trauma Patient Simulator (VMT-TPS) (Research Triangle Institute [RTI], 1998) is such a system. The VMT-TPS, formerly known simply as VMT, allows training of pre-hospital emergency care and is specially suited for multi-trauma patient assessment. It provides a graphic, on screen portrayal of a synthetic casualty and provides some limited ability to offer treatment. It serves as an excellent initial wound assessment tool, due to its visual nature. The ability to display bleeding at critical points on the body is a key feature for its use as a casualty assessment tool.

Another model useful in initial assessment is MediSim (Stansfield et al., 1998). MediSim is a prototype virtual reality training system, targeted primarily at training the combat medic, who has the responsibility to stabilize and sort multiple casualties for evacuation to field hospitals. This focus differentiates MediSim from some other virtual reality medical trainers, whose primary goal is to train a specific procedure or task. The goal of the MediSim trainer is to train rapid situational assessment and decision-making under highly stressful conditions. Realistic visual queues are key to MediSim's ability to train initial assessment of combat trauma.

Operational Requirements-based Casualty Assessment (ORCA) is U.S. Government-owned software developed by the Crew Casualty Working Group (CCWG) (Klopcic, Neades, & Tauson, 1998). The CCWG is in the fifth year of a five-year joint project between the Joint Technical Coordinating Group (JTCG) for Munitions Effectiveness and the JTCG on Aircraft Survivability. The major product of the project is a comprehensive methodology, with supporting data, for assessing the effects of conventional munitions upon the ability of personnel to perform military tasks. The tangible result of the project is the computer program called ORCA. In the ORCA community, a threat environment that has actually reached a person is called an insult. The insults included in the CCWG charter include:

Penetrators (fragments, bullets)

Blast overpressure

Thermal fluence

Toxic gases, both military agents and combustion products

Abrupt acceleration

Blunt trauma

Laser eye damage

The ORCA methodology tracks INSULT to INJURY to IMPAIRMENT to JOB PERFORMANCE, using degradation of performance functions based on 24 Elemental Capabilities. These capabilities describe those things that the normal human body is generally capable of doing (e.g. Visual Acuity and Color Discrimination). Therefore, the effects of various types of injuries are determined and their degradations of the body are mapped over time.

ORCA provides very specific injuries. The human body is defined and geometrically modeled by 473 ORCA Body Components (OBC's). Each one basically relates to an organ of the body. Each OBC has associated with it a scale in which its condition (extent of injury) is expressed. Insult to an OBC causes an injury, which is quantified in a data structure called the "A" Vector. The term "vector" refers to a one-dimensional array, or series of objects of the same size and type. Each OBC has associated vulnerability categories, which are used to determine which damage algorithms to use in the injury determination process. Additionally, various physiological processes, called "B" Processes (i.e. bleeding) result and further quantify the injury.

As the body loses critical functions, its ability to perform certain tasks also diminishes, resulting in an affect on job performance and, collectively, the unit's mission performance. ORCA attempts to answer the question: How will these type injuries in this quantity affect my unit's ability to perform its wartime mission?

More detailed discussion on ORCA, including description of insult types and outputs, may be found in Chapter Two.

1.4.3 Military Applications

A lower limb trauma simulator is being evaluated for the Medical Combat Casualty Care training course at Fort Bragg, NC Medical Training Center (Satava & Jones, 1997a). As part of the Advanced Trauma and Life Saving part of the course, a visual 3-D representation of the thigh from the Visible Human has a gunshot wound created from accurate ballistic wound data. In a typical scenario, the medic uses virtual instruments to perform wound debridement.

1.5 Interoperability in a High Level Architecture (HLA) Environment

Many of the currently used medical simulation models offer particular training in a specialized area. There are currently no simulated medical training systems available that allow for realistic simulation of total-body casualty care at various levels and in various environments. Nor is it known if in the near future a comprehensive model will be developed. A comprehensive model would appear to be very expensive. Additionally, the specialized nature of modern medicine promotes specialized tools as seen from the discussion above. The basic assumption is that simulation interoperability is the preferred methodological approach. Interoperability offers flexibility, while permitting powerful individual simulations to develop independently of the system. Finally, and equally important, there is no medical training system which promotes High Level Architecture (HLA) interoperability among various types of simulated medical components.

The Department of Defense (DOD) Modeling and Simulation Master Plan (DOD, 1995) calls for the establishment of a HLA for modeling and simulation and mandates that all future simulations will be HLA compliant.

Before proceeding further, it is important to define a few key HLA terms. The formal definition of the DOD HLA comprises three main components. These components are: 1) the HLA Rules (Defense Modeling and Simulation Office [DMSO], 1998), which describe the responsibilities of simulations and of the runtime infrastructure (RTI) in HLA federations, 2) the HLA Interface Specification (DMSO, 1997a), which defines the interface functions between the RTI and simulations participating in HLA federations, and 3) the HLA Object Model Template (OMT) (DMSO, 1997b), which represents a common presentation format for HLA Object Models. There are two types of object models in HLA, the Federation Object Model (FOM) and the Simulation Object Model (SOM). A FOM is a specification of the exchange of public data among the participants in a HLA federation. A SOM is a specification of the information types offered to federations by individual simulations.

1.6 Combat Trauma Patient Simulation (CTPS)

The Combat Trauma Patient Simulation (CTPS) research team is prototyping and evaluating a training and analysis simulation system that realistically simulates the emergency medical treatment process from the time of injury through initial treatment at a field hospital (Rajput et al., 1997). The CTPS team is composed of members from the DOD Live Fire Test and Evaluation Office, US Army Simulation Training and Instrumentation Command (STRICOM), the University of Central Florida's Institute for Simulation and Training (IST), Lockheed Martin, Medical Education Technologies, Inc. (METI), and the Training and Simulation Technology Consortium. The University of Central Florida (UCF) is also providing technical assistance from members within the departments of Industrial Engineering and Management Systems, Health and Public Affairs, and Computer Science.

The premise of this research project is that "virtual casualties" can be simulated by realistic physical simulations from the time of initial trauma throughout treatment and transportation. The goals of the project are to decrease the deaths due to combat wounds by having better trained medical staffs and to provide a mechanism for analysis and for test and evaluation (T&E) of issues in casualty medical treatment.

The most visible component of this system is a physical simulation of a casualty (an instrumented electro-mechanical mannequin), the Human Patient Simulator (HPS). The HPS is a model-driven system. Sophisticated physiological and pharmacological models determine virtually all simulator responses. Patient physiology is defined by patient profiles and can be modified either "on-line" or through scripts. The HPS was originally developed for training anesthesiologists and provides a dynamic, physiologically accurate simulation of a patient whose condition must be diagnosed, treated, and monitored.

Injuries are input to the CTPS via the MILES II ECC, stored as "patients" in an IST-developed software patient simulator known as PATSIM, and transmitted for manifestation on an HPS. The transfer of patients from one CTPS component to another is controlled by the CTPS Executive (Rajput & Petty, 1999). HLA provides a flexible infrastructure for connecting the disparate simulations to form a larger distributed simulation. In HLA terms, the CTPS system is an HLA federation.

The current CTPS system does not provide multiple, high-definition combat injuries for manifestation on the HPS. The combat medical training community needs a more comprehensive simulated training system that generates realistic combat casualties for a federation of simulation systems. Injury-induced symptoms need to be realistically manifested in a manner that allows for high fidelity training and feedback on critical life-saving tasks.

1.7 Focus of Research Effort

In order to successfully address and possibly overcome the above limitations, it is necessary to focus the research effort. Since simulated medical training must start with a casualty, the research will first focus on current simulated injury generation and categorization methods, identifying strengths and weaknesses as applicable. Secondly, the research will analyze the ORCA insults, looking closely at output and how it might be pertinent to other current medical simulations (e.g. CTPS). Finally, since CTPS components must operate in an HLA environment, the research will look at ongoing efforts to develop medical SOMs and FOMs.

CHAPTER 2

2.1 Injury Generation and Categorization Methods

2.1.1 DEPMEDS Codes

The Deployable Medical Systems (DEPMEDS) is a DOD initiative which projects and deploys medical material to various theaters of operation (Gauker & Reed, 1997). As part of the methodology for determining logistical requirements for different situations and areas of operation, a series of patient condition codes was developed. These approximately 350 codes (the number continues to grow) describe patient conditions likely to be encountered during military operations. About two thirds of the codes describe trauma cases, making them suitable for modeling in ORCA. The other one third describe non-traumatic conditions, applicable to a Troop Medical Clinic (TMC) or a longer term care facility.

The DEPMEDS codes are used by current simulations in a number of ways. The Medical Readiness Learning Initiative (MERLIN), uses algorithms developed by subject matter experts to represent patient condition, as described by the DEPMEDS codes (DOD, 1998). Other simulations use the codes as a method of transmitting virtual patients to distant medical treatment facilities. When generated in the proper mix and quantity, the codes are capable of realistically representing patient conditions for various scenarios.

DEPMEDS patient condition codes do not define specific physiological effects of injuries. However, they do provide enough detail to drive medical logistical requirements and would serve as an excellent reference database for anyone interested in limiting training scenarios to specific types of injuries (e.g. head wounds).

2.1.2 Abbreviated Injury Scale (AIS) Codes

The AIS codes (American Association for Automotive Medicine, 1985) represent a standard for assessing impact injury severity (widely accepted within the emergency medical care community). Born from the idea that classification of road transport injuries by types and severity is critical to their etiological study, the AIS was originally published in 1971. Its developmental sponsors were the American Medical Association, American Association for Automotive Medicine and Society of Automotive Engineers.

The AIS is a system that codes single injuries and it forms the foundation for assessing patients with multiple injuries. The AIS 80 committee recommended and subsequently indorsed the method of Maximum AIS (MAIS). The premise of MAIS is that the most severe AIS code should be used as the surrogate for assessing overall injury severity. Studies revealed that approximately 98 percent of patients would be properly assessed using MAIS. This method eliminated subjective judgement and could be assigned by a nonmedical coder.

Another AIS derived method of injury scaling is the Injury Severity Score (ISS). The ISS is a mathematically derived code determined by adding the squares of the highest AIS codes in each of the three most severely injured regions of the body.

Penetrating injury was incorporated into AIS 85. This step highlighted the fact that although the AIS was originally developed for impact injury assessment, its global recognition as a standard for injury severity data collection may warrant further expansion to encompass all injury types.

There is no apparent relationship between the DEPMEDS and AIS codes, other than they both are used to describe patient conditions. A single DEPMEDS provides an excellent general description of the total patient condition, while the AIS codes must be grouped, deciphered, and analyzed, in order to provide insight into the overall condition of the body. AIS codes provide more detail for a specific injury.

2.2 Analysis of Phase I CTPS

The following section is based on the CTPS Phase I Final Report (Rajput et al., 1997). The data contained in the referenced document serves as the basis for any future enhancements to the CTPS and provides excellent insight into the HLA-driven architecture of the system. The figures and tables serve to provide a better understanding of the system architecture and to highlight current methods of CTPS injury generation.

Figure 1 depicts the CTPS Phase I architecture. In addition to portraying the architecture, this section will briefly discuss CTPS information flow and injury generation.

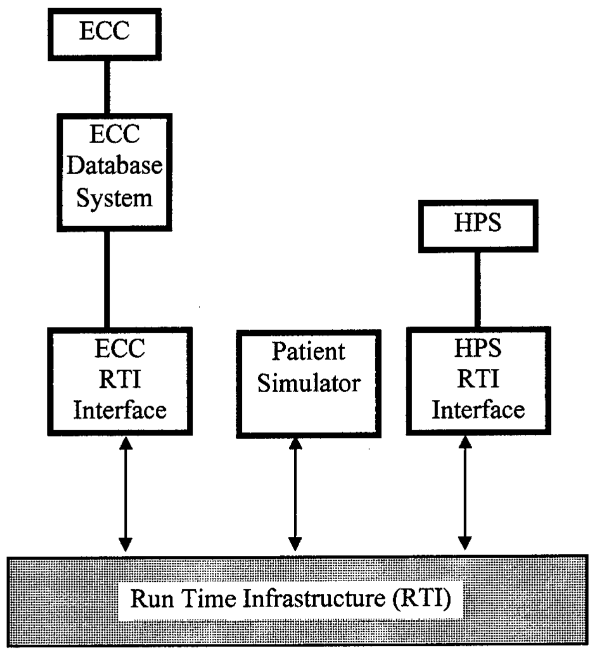

Figure 1: CTPS Phase 1 Architecture (Reprinted from Rajput et al., p. 9)

2.2.1 CTPS Information Flow

CTPS information flow is as follows: 1) the ECC federate transfers ownership, via the RTI, to PatSim; 2) the PatSim federate transfers ownership, via the RTI, to HPS; and 3) the HPS federate transfers ownership back to PatSim, via the RTI.

2.2.2 Injury Generation

In the CTPS, patient simulation begins with the generation of an injured patient by the ECC. Next, the information is transferred to PatSim, then to the HPS. The CTPS Phase I design allows the physiological/pharmacological patient attributes to be simulated by the HPS, since it is most suitable for simulating these attributes. Administrative categorization of attributes concerned with wound type and severity are best handled by the ECC.

It is important to highlight the patient flow during the injury generation process. The CTPS patient attributes, as well as who owns them, is depicted in Table 1. In response to a MILES/SAWE "hit", virtual patients are created at the ECC. When the virtual patient receives a treatment selected by a medic, the ECC sends patient information to ECC Database Translator. Once the ECC Database Translator captures this information, it retransmits it to the ECC RTI Interface. The ECC RTI Interface creates the patient in the CTPS federation through the RTI with a "Request ID" service call, and informs the federation of the initial attribute values through the RTI "Update Value" service calls. Note that the first nine attributes are produced by the ECC. Also note that attributes 6-9, the physiological attributes of blood pressure, respiration rate, and heart rate, are transferable attributes. This is a key point in that ECC produces a "one shot" update of these attributes (represents patient state at time zero), then passes them on to be monitored and updated by another federate component.

P = Permanent Ownership of Attribute T = Transference Among Simulators

Attribute	Abbrev	Static/ Dynamic	Physiological/ Non Physiological	ECC	HPS	PatSim
Trauma Type		Static	Non Physiological	P		
Weapon Type		Static	Non Physiological	P		
Body Area		Static	Non Physiological	P		
Wound Severity		Static	Non Physiological	P		
Recommended Action		Static	Non Physiological	P		
Location		Dynamic	Non Physiological	P		
Blood Pressure	BP	Dynamic	Physiological	T	T	T
Respiration Rate	RR	Dynamic	Physiological	T	T	T
Heart Rate	HR	Dynamic	Physiological	T	T	T
CO2 Arterial Partial Pressure	CO_2APP	Dynamic	Physiological		T	T
O2 Arterial Partial Pressure	O_2APP	Dynamic	Physiological		T	T
Arterial O2 Saturation	O_2SAT	Dynamic	Physiological		T	T

Table 1: Patient Attribute Details (Reprinted from Rajput et al., p. 11)

2.2.3 Phase I Injury Types

For Phase 1, METI developed three combat trauma types: Anaphylaxis, Pneumothorax, and Blood Loss. These trauma types are implemented as scenarios that execute on the HPS in response to the corresponding values of the wound type. The relationships between trauma and wound types are shown in Table 2.

Combat Wound Scenario	Combat Trauma Type
Snake Bite scenario	Anaphylaxis
Gunshot Wound To Chest scenario	Pneumothorax
Land Mine Explosion scenario	Blood loss

Table 2: Wound Scenarios and Trauma Types (Reprinted from Rajput et al., p. 14)

2.2.4 ECC Phase I Modifications

To meet the requirement of the CTPS design, ECC firmware was modified to be triggered/hit by three specific types of weapons: 1) M16/ M60 Machine Gun, 2) M2/ M82 Machine Gun , and 3) AT-3 SAGGER-NTC. The wounds caused by these three weapon types are Blood loss, Pneumothorax, and Anaphylaxis, respectively. Currently, all casualties are generated from a single ECC.

2.3 Analysis of ORCA

As previously stated, the ORCA charter calls for development of seven insults. The ORCA Alpha + software version (Frew, Gray, Killion, & Streit, 1997), upon which this research is based, had working modules for four of these insult types: Penetrators (fragments), Blast overpressure, Thermal fluence, and Toxic gases (military agents). Since the ORCA charter takes it beyond the scope of medical concerns, it was necessary to focus the research to a specific area of the ORCA program. Figure 2 depicts the ORCA taxonomy and the specific area of research concern. What follows is an overview of each of the working insult types.

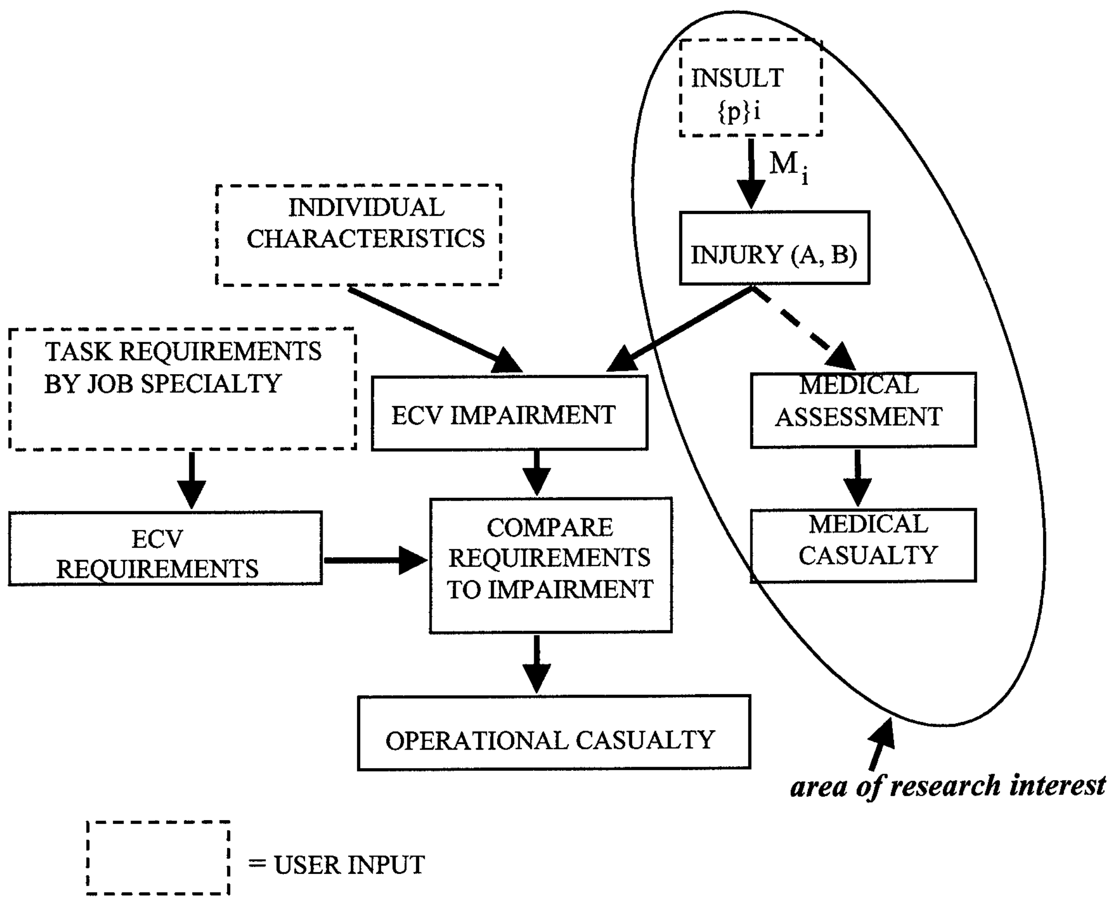

Figure 2: ORCA Taxonomy (Klopcic et al., 1998) With Area of Research Interest

2.3.1 Penetration Insult Overview

The penetration insult is the most robust of the ORCA insult types and is therefore covered in more detail than other insult types. In addition, some of the same output formats used by the penetration model are the same for other insults. ORCA uses the ComputerMan model for evaluating an expected level of incapacitation due to fragments (Frew et al.,1997). This methodology includes: a computerized human anatomical model, the ability to trace a ray through the human starting at any point, algorithms for penetrator retardation and resulting organ damage, and mapping to injury scales (Abbreviated Injury Scale (AIS) Code). The model can process single fragment shots, a grid of shots, or a point-burst spray of fragment shots.

2.3.1.1 Penetration Input Parameters

For penetration, ORCA uses the following insult parameters: penetrator description, penetrator impact conditions and body orientation. The penetrator description includes the mass, shape, material, and orientation upon impact. The impact conditions include the fragment velocity and impact location. The body orientation refers to the position of the body (e.g. standing). Currently, the user selects insult type and parameters using the ORCA pull-down menus and keyboard. The ORCA GUI displays the human anatomical model on the screen, allowing the user to select penetration entrance and exit wounds via the mouse. Applied Research Associates (ARA) states that a future ORCA version may have the ability to read batch files as input.

2.3.1.2 Penetration Insult Output

ORCA allows display of injury data to screen, file, or both. Data is output to a Injury Summary screen (or file). The data displayed or written to a file is retrieved from the current injury severity structure. The Injury Summary lists each OBC affected, followed by total damage to the affected OBC. Total damage is listed as either a percentage of damage or surface area damaged, depending on the OBC type. Additionally, the Injury Summary lists any deleterious processes initiated by the injury. A "view process" radio button allows the user to get a more detailed account of the process. The detailed account (for bleeding process) includes the following:

- Number of wounds
- Organ type affected (OBC type)
- Size of the wound (sq cm)
- Initial blood loss rate (liters/min)
- Shock volume (liters)
- Time to onset of shock (min)
- Final stats (time to cessation of bleeding, total blood loss, and residual capability factors at immediate, 30 sec, 5 min, 1 hr, 24 hrs, and 72 hrs)

For a penetration wound, the user also has access to a "view AIS" radio button, which displays the AIS description from the Penetration insult. The AIS description output includes the AIS code (5 digits, followed by a decimal and one last digit – e.g. 10503.2), AIS body region (e.g. Thorax), and AIS Severity (e.g. moderate).

2.3.2 Blast Insult Overview

ORCA uses two methodologies for calculating blast injury affects (Frew et al., 1997). The first pertains to injuries of the lung and thoracic region and uses an injury model developed by the Walter Reed Army Institute of Medicine. The second model calculates injury to the ears, using one of two options. Either model can use a user-defined data file or the simple Friedlander or Triangular waves to determine eardrum rupture or hearing loss.

2.3.2.1 Blast Input Parameters

The blast input parameters are described by the blast/overpressure and the body orientation. The user has three options (Friedlander, Triangular wave, or data file) for defining the blast/overpressure data. For each option, the user may view the data on a time history plot.

Body orientation is important, because blast waves cause different levels of injury based on the amount and type of waves hitting the thorax. The three choices for body orientation are: long axis of the body parallel to the blast winds, long axis of the body perpendicular to the blast winds, and thorax near a reflecting surface and perpendicular to the blast winds.

2.3.2.2 Blast Insult Output

The blast insult produces injury output in the same summary format as the penetration injury, minus the AIS codes. An important consideration is that blast injuries affect only the lungs and the ears, so the blast injury output will only reflect damage to the OBC's pertaining to these regions. In addition, an internal respiration process will occur and it will be output as "Percent of Lung Volume Lost" at various times (immediate, 30 secs, etc.).

2.3.3 Thermal Exposure Insult

ORCA uses the BURNSIM program as the thermal insult model (Frew et al., 1997). F.S. Knox, III, Ph.D. and the U.S. Army Aeromedical Research Laboratory (USAARL) developed this model. BURNSIM represents the skin as 12 nodes, or skin depths, and predicts the total damage and threshold depth at each node.

2.3.3.1 Thermal Exposure Input Parameters

The user must enter values for exposure time, skin diffusion data, and exposed tissue surface areas. The ORCA GUI offers fill-in-the-blank menus for easy data entry. Many of the blanks are pre-filled with default values. For surface areas affected, the user can choose from among hand, elbow, knee, foot and ankle, sole of foot, external ear, periorbital, scalp area, and other non-specified area. For areas with both a right and left entity (e.g. ear), the user may choose either or both sides.

2.3.3.2 Thermal Exposure Insult Output

The model outputs the total skin damage and the threshold depth (skin depth) for each of the 12 nodes. The model represents and outputs data on 12 nodes for each of the exposed tissue areas.

2.3.4 Toxic Gas Insult Overview

ORCA utilizes the ChemicalMan model, developed by ARL, for computing the affects of toxic gas (Frew et al., 1997). ChemicalMan was written in FORTRAN, but the code was translated into C for inclusion in ORCA.

2.3.4.1 Toxic Gas Input Parameters

Input parameters include the exposure time, the vapor concentration, and the agent (GA, GB, GD, GF, and VX). Future versions may allow alteration of the soldier parameters (body weight and respiratory rate), currently set as default values of 70 kg and 15.01 breaths/min, respectively. Additionally, future version will allow the user to choose between "combustion products" and "military agents". The current ORCA version only works for "military agents".

2.3.4.2 Toxic Gas Insult Output

The toxic gas insult displays graphic information to the screen and text information to file. The output formats differ considerably. The screen output displays a color-coded graphic of severity for various physiological categories. These are mental, visual, cardiovascular, visceral, and limbs. The file output lists severity levels at various concentration times (2 sec intervals), as well as Toxic Vapor Symptoms at immediate (1 sec), 30 seconds, and 2 minutes.

2.3.5 Directed Energy Insult Overview

ORCA uses this insult to predict laser damage to the eyes (Frew et al., 1997). The methodology for this insult was developed by Bob Miller, Ph.D. and Brad Carver of Systems Research Laboratories, and implemented by ARA. Laser exposure causes eye injuries such as flashblindness, retinal damage, and corneal swelling.

2.3.5.1 Directed Energy Insult Input Parameters

The required user inputs are laser type (continuous wave or pulse), laser properties (wavelength, intensity at cornea, duration, pulse repetition frequency, pulse width), and eyes affected (L, R, or both). As with other insult types, the fill-in-the blank menus drive the input process.

2.3.5.2 Directed Energy Insult Output

The output (to screen and file) includes a summary of the input parameters, along with a degree of injury for each injury type (flashblindness, retinal damage, and corneal swelling). The degree of injury is expressed in the degrees of visual angle (arc) affected and length of time to recovery. If a certain type of injury does not occur (e.g. corneal swelling) then the returned injury value is "no".

2.3.6 Summary of ORCA Output

2.3.6.1 Data Structure

Although the ORCA data is not structured in a hierarchical manner, definitions are in place to make the transition to hierarchical design a smooth one. Figure 3 shows how the ORCA Vulnerability categories and OBCs may be placed in a hierarchical order as classes and subclasses.

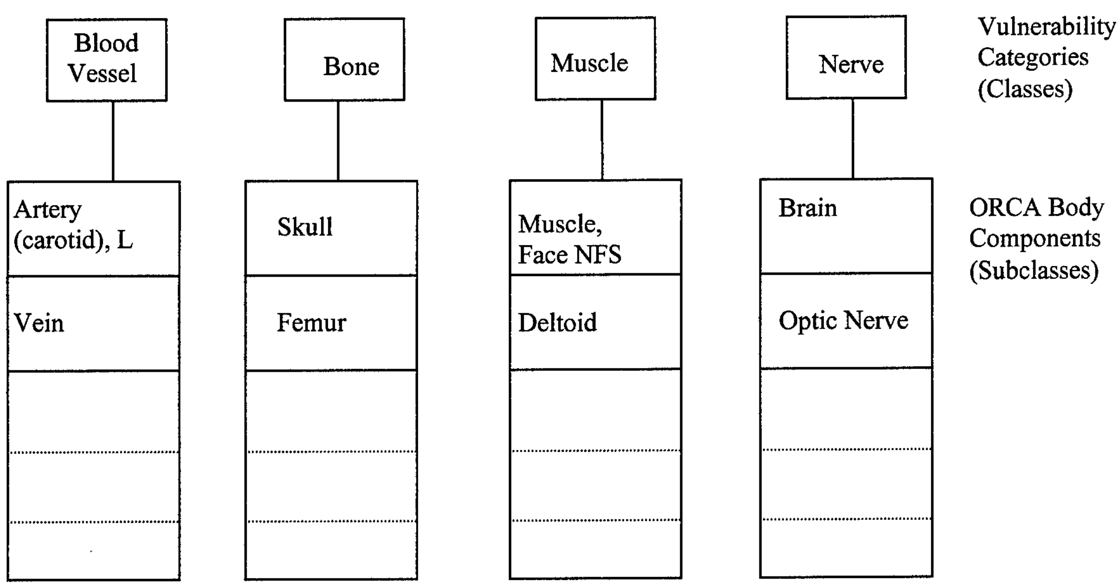

Figure 3. Example Implementation of ORCA Hierarchical Design

2.3.6.2 Possible ORCA Attributes

In examining output from each of the ORCA insult types, it is clear to see that the penetration insult produces output most applicable to combat trauma simulation. A number of useful attributes can be obtained from the penetration insult output. These include:

- damage to the affected OBCs
- initial blood loss rate
- time to onset of shock
- percentage of lung volume lost
- AIS code (body region/organ affected/level of injury based on anatomy/severity)
- survival probability (based on ISS)

All of the above attributes, with the exception of time to onset of shock and survival probability, are considered static; they would be passed once through the RTI as part of the patient profile at time zero. They would provide significant detail concerning the patients specific level of injury and near term survival probability. Since ORCA provides no dynamic physiological attributes, it is essential that the ORCA output be combined with the ECC dynamic physiological attributes (blood pressure, respiratory rate, and heart rate) in order to simulate a realistic patient.

Appendix A contains example output from an ORCA penetration insult. The blast insult also provides data suitable for combat trauma patient simulation, but it is limited to percentage of lung volume lost and ear damage.

2.4 MYSTECH Work

2.4.1 MYSTECH Physiological SOM

Mystech Associates, Inc. developed a Physiological SOM for stimulation of a mannequin (Lyell, 1998), which incorporated the human respiratory and cardiovascular systems, along with the corresponding nervous system components.

Initial research compared the Mystech SOM subclasses, listed in the Object Class Structure Table with the ORCA OBCs (473 total). There were 68 direct subclass name/OBC matches. It is possible that the 44 additional Mystech subclasses are present due to greater specificity concerning certain nervous system components. The over 100 Mystech subclasses, when compared with the 473 OBCs, highlights ORCA's "total body" representation of human physical anatomy. Since the cardiovascular, respiratory, and nervous systems form the core of human functional physiology, the Mystech Physiological SOM will serve as a fine anatomical foundation (both physical and functional) for development of a "total body" Physiological SOM.

2.4.2 MYSTECH Human Response to Stimuli SOM

In developing the Stimuli SOM, Mystech concluded that the first order response of the body is not determined by the Stimuli Federate (Lyell, 1998). This means that the structure of the Stimuli SOM will not include physiological objects.

The Mystech Physiological SOM guided the development of the Mystech Stimuli SOM. Since the Physiological SOM focused on the respiratory and cardiovascular sytstems, the Stimuli SOM only included those stimuli that affect these systems. With this approach, the size of Stimuli SOM increases proportionally with the size of the Physiological SOM. For example, if we add eyes to the Physiological SOM, then we would want to include all stimuli that affect the eyes in the Stimuli SOM.

Mystech also concluded that the structure of the Stimuli SOM is adequate for representing non-visual simple stimuli (Lyell, 1998). Simple, in this context, is defined as a stimulus which has one simple identity vis-a-vis the body. This conclusion was reached through expert medical consultation, resulting in definition of the things that the physical body must know about a particular stimulus: 1) how much of the stimulus is present, 2) how much of the stimulus must be present to cause an affect, 3) how fast acting is the stimulus, 4) what are the features (identity) of the stimulus, and 5) what is the primary target system of the stimulus. These knowledge requirements were translated into Informational Attributes, housed as complex datatypes within the structure of the Stimuli SOM. They are: identity profile, potential level of injury, immediacy of effect, and target system (of the stimulus). A more detailed description follows.

In the Response to Stimuli SOM, the "Identity Profile" uses the complex datatype "Identity Profile Data". The fields are Boolean and describe the possible effects of the stimulus (e.g.. Modify Ambient Air Properties? or Bind Hemoglobin?). The “Potential Level of Injury” attribute utilizes the complex data type “Generic Level of Info”, containing two fields. The first is “Level” and the second is “Potential Injury”. The third informational attribute is “Immediacy of Effect”. This attribute uses datatype “Immediacy of Effect Data” to describe how fast-acting the stimulus is. Example entries in “Immediacy of Effect Data” include “immediate” and “seconds”. The final informational attribute is “Target System”. The system should be some physiological component. The specificity of the component will depend on the specificity of the stimulus. In other words, the “target system” for stimulus “1/2 inch needle” should not be “liver”, because it can’t affect it. A more suitable “target system” in this case might be “epidermis”.

The Stimuli SOM is capable of expansion to include stimuli types beyond those that deal solely with the respiratory and cardiovascular systems (Lyell, 1998). One method, termed a “flat extension”, is simply to add new fields to “Identity Profile Data”. This approach would work for addition of simple stimuli, but more effort is required for complex stimuli. Complex stimuli possess the capability to simultaneously alter the state of more than one target system. As stated by Lyell, “the increased complexity of the recipient system feeds back into the representation of the stimuli and requires a more complex representation of the stimuli, since this representation is done vis-a-vis the recipient body” (p. 45).

2.4.3 MYSTECH FOM

Mystech developed two versions of the "Human Response to Stimuli" FOM (Lyell, 1998). In version one, a sophisticated "Body Environ Matrix" object forms the core. All other physiological objects must communicate with it via publish/subscribe services. A possible limitation of this FOM is that physiological details are hidden. This would make it more difficult to add members to the federation, without having to first revisit the Physiological SOM and subsequently develop a totally new FOM.

Mystech FOM Version Two is simply a union of the Physiological and Response to Stimuli SOMs and is an excellent FOM for expansion. This research focuses on possible expansion of this FOM, through the addition of new objects and attributes from ORCA.

2.5 Chapter Summary

Before proceeding, it is important to summarize the completed research. The research has taken a look at some current methods of injury generation and categorization (DEPMEDS and AIS) and discussed their impact or possibilities for use with medical simulations. An overview of phase I of the CTPS program identified the ECC as a key component, capable of producing time zero physiological patient attributes. The research analyzed ORCA output, discussed possible ORCA attributes, and outlined a methodology for placing ORCA output into a hierarchical design. Finally, the research discussed efforts to create robust medical SOMs and FOMs that are capable of supporting a variety of simulations.

2.6 Research Questions

This research addresses the general question: What is the potential to advance medical simulation interoperability and fidelity, given leading simulation systems? This research will take advantage of two advanced medical simulators, the Operational Requirements-based Casualty Assessment (ORCA) program and the Combat Trauma Patient Simulation (CTPS) to research the gap in the current simulated medical component. The research will then progress into development of theoretical and working models that answer the questions: 1) Can the CTPS manifest symptoms of virtual patients afflicted with ORCA-generated injuries onto the CTPS FOM; 2) Which of the ORCA insult types can the CTPS accommodate?; 3) What injury types can CTPS handle that ORCA can not generate?; 4) What is the most effective way of integrating ORCA into CTPS?

CHAPTER 3

3.1 Research Methodology

This research has identified different methods for generating and categorizing injuries, and taken a look at their applicability to combat trauma simulation. Now the effort will proceed to presentation of a prototype injury generation model using ORCA and conduct of research into incorporating injuries into that model. To demonstrate the viability of the injury generation model, initial research will use this model to develop an injury database. The injury database, once developed, will provide a mechanism for storing injury "profiles", which may later be used as initialization data for CTPS patients. The research will highlight CTPS testing, conducted to determine the feasibility of reading patient injury data from such a database. In order to decide which types of injuries to include in the database, the research makes a determination as to the suitability of ORCA output for use by CTPS. Further analysis of potential CTPS capabilities will highlight injury scenarios that ORCA is not capable of supporting. The research attempts to build on previous work by identifying relationships between ORCA objects and attributes and those from the Mystech Physiological and Stimuli SOM. Research into the development of an ORCA-derived Injury SOM, along with analysis of its relationship to the current CTPS FOM and the Mystech-derived CTPS Phase III version 0 FOM, will shed light on the possible future of CTPS.

As a recommendation for future research, this work explores the need to continue building on Mystech's efforts in an attempt to ultimately produce a FOM robust enough to handle even the most visually intense total-body simulations.

3.2 Injury Generation Using ORCA

A proposed model for injury generation is portrayed in Figure 4. A key feature of this figure is that data concerning wound type and severity gets more specific as you traverse the figure from left to right, top to bottom (from Electronic Casualty Card (ECC) injury to ORCA induced injury).

The injury begins with an instrument of causation (weapon type). These types are inherent in the MILES ECC database and are the same ones used in Phase I of the CTPS project. The specified weapon causes a particular type of injury. This injury is selected randomly from a group of injuries which would realistically be caused by the specified weapon. As far as CTPS is concerned, this ECC injury consists of the nine attributes. These are trauma type, weapon type, body area, wound severity, recommended action, location, blood pressure, respiration rate, and heart rate. It is important to make a key point at this time. The fact that the ECC provides the three physiological attributes (blood pressure, respiration, and heart rate) for a particular injury is of the utmost importance. Other methods of defining injury (ORCA and AIS codes) have focused on physical anatomy and those changes to physical anatomy produced by an insult. ORCA does not provide physiological attributes. It does describe respiratory and bleeding processes, in response to insults but not to medical interventions. The fact that we can relate the measurements of certain physiological attributes (e.g. heart rate) to a particular injury type allows us to define a patient at state zero (immediately following injury).

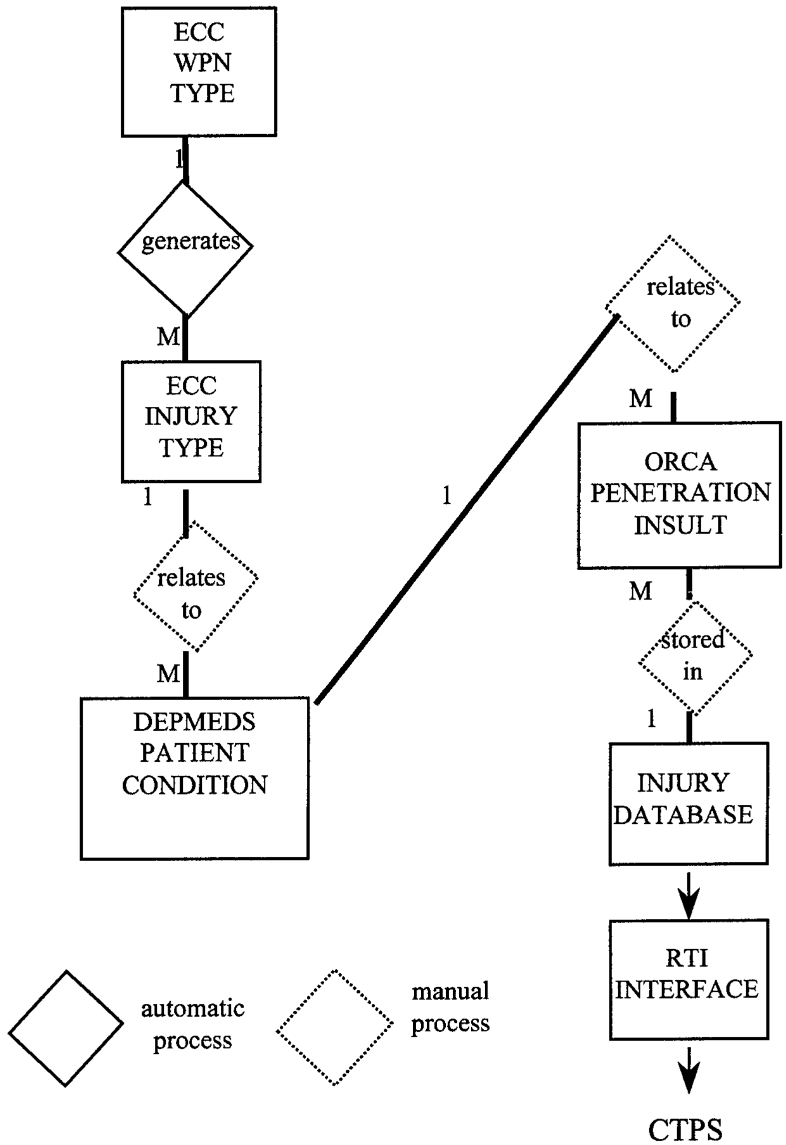

Figure 4. Proposed CTPS Injury Generation Model Using ORCA

Although the ECC provides a number of attributes, including the important physiological ones, the attributes concerning wound type, body area, and severity are still relatively non-specific. The data from these attributes may be used to select from more specific DEPMEDS patient condition codes, which might result from the type of injury described by the ECC. Once a specific DEPMEDS code is determined, the injury information is specific enough to model using ORCA. ORCA further specifies the injury, creating a comprehensive injury profile. Various injury profiles can correspond to a specific DEPMEDS code. However, since the ORCA injury profiles are manually modeled to closely resemble a given DEPMEDS patient condition, there is a subjective range of injury profile data that reasonably relates to each DEPMEDS code. Venture outside of this range and you possibly describe a different DEPMEDS patient condition. Each ORCA injury profile can be saved to file. A collection of these ORCA injury profile files can be used for constructing an injury database, partially depicted in Table 2 on the following page.

ECC Wpn Type	ECC Area	ECC Inj Type	ECC Sever -ity	DEP-MEDS Codes	Inj Prob	ORCA Injury Profile	Dam-aged OBC	Dam-age Done	Lung Vol	Blood Loss Rate
27	11	4	18	124	0.33	10	1	1.58		0.15
							2	1.50		
							306	<20		
							139	Frac		
							321	<.20		
							278	>.50		
							188	<.20		
							303	<.20		
						11**				
						12**				
				121*	0.33	20**				
				122*	0.33	30**				
27	6	4	25	176	0.1	40	1	0.36		1.1
							2	1.60		
							70	<.20		

Table 3 – Partial Prototype Injury Database

* - DEPMEDS codes that are applicable for the given ECC injury, but have not yet been modeled using ORCA

** - ORCA Injury Profiles that are applicable to the given DEPMEDS condition, but have not yet been developed

3.3 The Injury Profile Database

The following are key points concerning the example data in the prototype database shown in Table 3:

- The sample injuries are generated by ECC weapon types 27 (M16) and 28 (artillery).
- One injury occurs to body area 11 (upper leg), another to body area 6 (abdomen), and the final two injuries affect body area 3 (chest).
- Three injuries are type 4 (penetration), while one is type 7 (blunt).
- The upper leg injury is of severity 18 (open penetrating – moderate), the severity of the abdominal wound is 25 (tissue loss – open – severe), the first chest wound is of severity 14 (lung – closed - respiratory distress – moderate), and the final chest wound is severity 36 (thorax – open – rib fracture – severe).

The following information relates to the DEPMEDS patient condition codes used in the database:

- **084**, Injury lung closed (blast crush) with pneumohemothorax moderate – one lung with pulmonary contusion and respiratory distress; hearing impairment moderate.

- **087,** Wound thorax (anterior or posterior) open penetrating with associated rib fractures and pneumothorax – acute severe respiratory distress.
- **124,** Wound thigh open lacerated penetrating perforating with fracture and nerve and/or vascular injury – limb salvageable.
- **176,** MIW abdomen and pelvis with penetrating perforating wound of liver and kidney.

The following additional information relates to the database:

- The "key" for runtime retrieval from the database consists of three ECC attributes (body area, injury type, and severity). All possible injuries are given equal probability, although this could change if there were reason to believe that one injury type was more common than another. Retrieval code might appear like this: "If body area = 11 and injury type = 4 and severity = 18, then DEPMEDS = 124 (probability 0.33)"
- While Table 3 relates a single injury profile to a DEPMEDS code, more can be done.
- For reference, the OBC descriptions are listed in Appendix B.

- For "damage done", the following applies: numbers represent square centimeters of surface area; > or < followed by a number represents percentage of total OBC damaged; "Frac" stands for "fracture"; blood loss rate is in liters/min.
- + and – are used to describe "go-no go" injuries (+ = "any damage")

The prototype database model was built utilizing the injury generation model discussed earlier. The database model uses the injury generation model to expand from the two current CTPS ECC-based injuries to thirteen possible CTPS injuries, through the extension available in DEPMEDS/ORCA object models. The database model is meant to show possible expandability, although each injury is modeled fully (using ORCA) to only one level. There are a number of important features of an injury database composed in the manner described above. The first of these is that the database model retains CTPS project continuity by linking to the ECC, a key player in the first phase of the CTPS program. DEPMEDS and ORCA data models also inherit physiological attributes from the ECC. Secondly, the database model includes the DEPMEDS codes, which will serve not only as an excellent reference list for the various injury types stored in the database, but also as a point of familiarity for users already familiar with DOD Medical Simulations. Lastly, the database model will include ORCA, which brings with it a host of specific attributes concerning damage to tissue, as well as data on the bleeding process and respiratory degradation.

3.4 Injury SOM Development

An injury SOM built around the previously discussed injury generation and injury database models must include classes and attributes from various CTPS components (ECC, ORCA), since they each play a role in injury profile development.

Development of an injury SOM needs to consider the proposed hierarchical design of ORCA data suggested earlier. A complete Injury SOM (in HLA Object Model Development Tool (OMDT) format is depicted at Appendix C.

In the proposed design, the OBC's may be looked at as subclasses, falling under their parent ORCA Vulnerability Category classes. The design depicts 12 human anatomical classes (bone, blood vessel, ear, eye, other tissue, hollow organ –hard, hollow organ –soft, lung, muscle, nerve, skin, and soft organ). It is important to note that some of the original ORCA OBC's and Vulnerability Categories have been altered or deleted in this design. Since the "go-no go" ORCA category did not fit well with other medical terminology, this category is renamed "other tissue." The "blood" vulnerability category (relates directly to OBC 469, the blood hemoglobin element) was deleted, due to the fact that OBC 469 is not "damaged" in the normal ORCA sense. The "blood" vulnerability category and OBC 469 are present merely to degrade the human elemental capabilities discussed earlier. The 473 OBC's fall within these 12 classes, with the exception of the aforementioned OBC 469 and OBC 229 (Peritoneum). ORCA lists the vulnerability category for OBC 229 as "NA". We will disregard OBC's 469 and 229 in further design schemes. All 12 classes fall directly under the CTPS base class "Casualty", as depicted in the partial Injury SOM of Table 4.1. The partial Injury SOM presented is incomplete in that all subclasses (OBC's) and attribute parameters are not represented.

Base Class	**1st Subclass**	**2nd Subclass**	**3rd Subclass**
Casualty (PS)	Bone (PS)	HeadOfFemurL	
		HeadOfFemurR	
	BloodVessel (PS)	Aorta	Abdominal
			Thoracic
		Artery	Jejunal
			AnteriorTibialL
		Vein	Angular
			AnteriorTibialR
	Ear (PS)	InternalL	
		InternalR	
	Eye (PS)	RetinaL	
		RetinaR	
	Other (PS)	Adrenals	
		BileDuct	
		Pituitary	
	HollowOrganHard (PS)	Bronchus	
		Larynx	
		Pharynx	
	HollowOrganSoft (PS)	Duodenum	
		Esophagus	
		GallBladder	

Table 4.1 Injury SOM – Partial Object Class Structure Table

Class	Attribute	Datatype	Update Type
Casualty	Location	GPSLocation	Static
	WoundType	WoundTypeEnum	Static
	WeaponType	WeaponTypeEnum	Static
	BodyArea	BodyAreaEnum	Static
	WoundSeverity	WoundSeverityEnum	Static
	BloodPressure	BloodPressureStruct	Conditional
	RespirationRate	unsigned short	Conditional
	HeartRate	unsigned short	Conditional
	BloodLossRate	unsigned short	Conditional
	LungCapacity	Unsigned short	Conditional
Bone	BoneDamage	BoneDamageEnum	Static
BV	BVDamage	BVDamageEnum	Static
Ear	EarDamage	EarDamageEnum	Static
Eye	EyeDamage	EyeDamageEnum	Static
Other	OtherDamage	OtherDamageEnum	Static
HOH	HOHDamage	HOHDamageEnum	Static
HOS	HOSDamage	HOSDamageEnum	Static
Lung	LungDamgage	LungDamageEnum	Static
Muscle	MuscleDamage	MuscleDamageEnum	Static
Nerve	NerveDamage	NerveDamageEnum	Static
Skin	SkinDamage	SkinDamageEnum	Static
SO	SODamage	SODamageEnum	Static

Table 4.2 Injury SOM - Attribute/Parameter Table

3.5 Testing the Models

This section describes research to test the feasibility of using the injury generation model, injury database model, and injury SOM. The research is divided into two distinct phases: pre-test and test.

3.5.1 Pre-Test Phase

This phase involves building a limited injury database model, using our injury generation model, to facilitate testing. An injury profile database will be built, incorporating ORCA generated injuries that correspond, to varying degrees, to the CTPS scenarios of blood loss and gunshot wound with pneumothorax. The third scenario planned for Phase II CTPS is snakebite. ORCA will not support modeling of a snakebite injury. It is important to note that if a FOM represented all of the objects and attributes read from the database, then the published attribute values would be updated throughout the federation. Since CTPS currently does not have such a FOM, the capability to fully test an ORCA-based injury SOM is somewhat limited.

3.5.2 Test Phase

The limited test will be conducted in the IST Lab, using the CTPS Phase II configuration depicted in figure 5. In this configuration, all federates operate in a

Windows NT environment, with the exception of ORCA (in dotted lines), which runs on a UNIX platform. The focus, for this particular portion of the research, is on the ORCA RTI Interface's ability to accurately read data from the injury profile database.

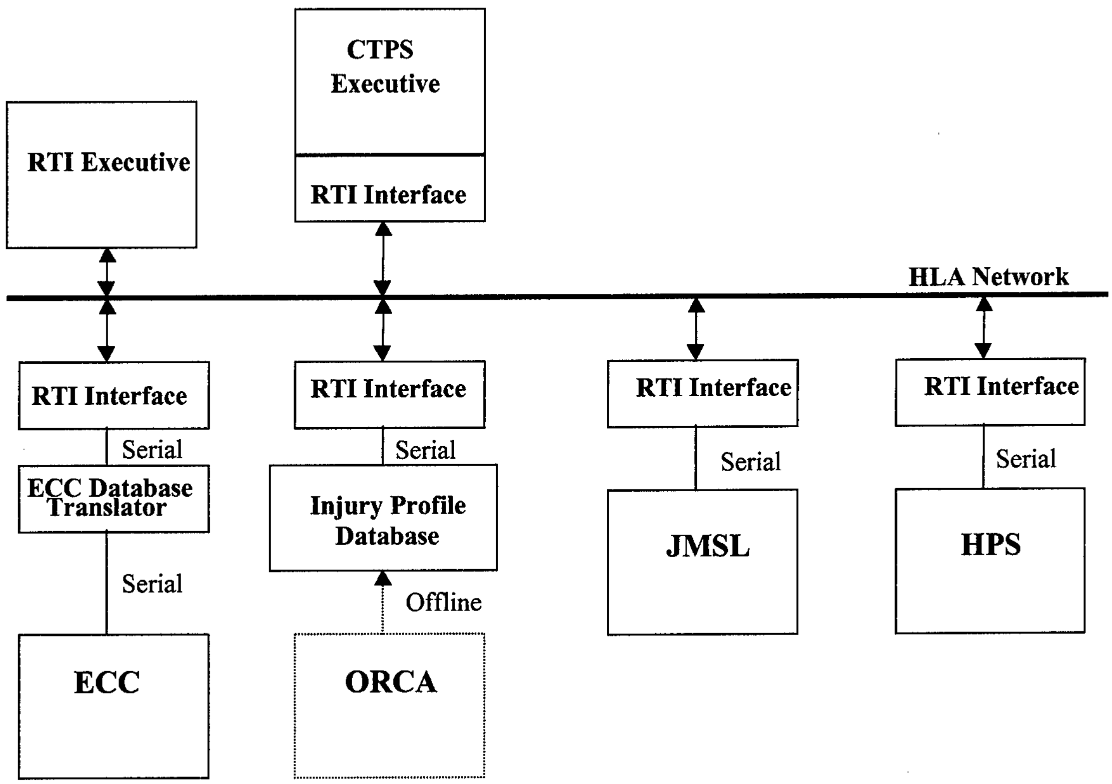

Figure 5: CTPS Test Configuration

Before leaving the test configuration, it is important to look at the structure of the Run Time Infrastructure (RTI) interface in more detail. The RTI interface structure is depicted in Figure 6. Two classes provide the interface between the federate (or simulator) and the RTI. These are the RTIambassador and FederateAmbassador classes. The RTIambassador class represents definition and implementation of the interface used by the federate to communicate with the RTI. The FederateAmbassador class defines the interface used by the RTI to talk with the federate. It is important to note that FederateAmbassador is an abstract base class that the federate developer must implement by defining appropriate sub-classes and methods, prior to compiling the federate with the RTI.

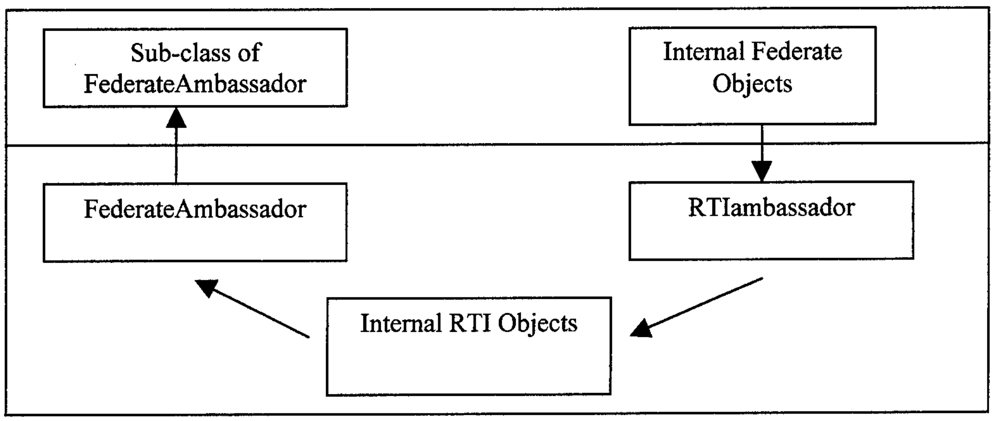

Figure 6: RTI C++ Interface

3.6 FOM Development

Unfortunately, the CTPS phase II FOM is scenario based. A scenario-based FOM places patients in certain "states" or subsets of various injury scenarios. For instance, a "blood loss" scenario might have several states in which the patient could be initially placed or moved to, depending on the situation. These states may be depicted in a manner such as "light", "moderate", or "heavy." In the blood loss case, the states would be characterized by the amount of blood loss occurring, most probably determined by an attribute like "blood loss rate."

Why does CTPS have a scenario-based FOM? If a FOM is not robust enough to handle all of the anatomical and pathophysiological changes that occur as a result of combat trauma type injuries and manifest them in such a way so that the medical caregiver can make an assessment of the patient state, then the alternative is to track patient state within specified scenarios. In other words, make the medical assessment beforehand and manifest symptoms appropriately, as opposed to manifesting physiological symptoms based on the pathology. Mention of the scenario-based CTPS Phase II FOM raises an important question. Exactly what type of FOM would be necessary to fully utilize detailed anatomical and pathological injuries such as those produced by ORCA? More discussion on this subject follows in Chapter 4.

CHAPTER 4

4.1 CTPS Phase II Testing With ORCA

Testing of the ORCA RTI interface was conducted at the Institute for Simulations and Training, Orlando, Florida in January, 1999. The following is a synopsis of the testing.

4.1.1 The Test Database

The injury database developed for testing was a text file, containing four injury profiles; three bloodloss and one pneumothorax. Each entry in the database was structured as follows:

#Bloodloss

27,176,Skin_NFS,SubcutaneousTissue,AbdomenNFS,Liver,KidneyR,UreterR,RenalR,Longissimus,.36,1.60,<.20,fracture>.50,fracture>.50,damage,>.50,<.20,-1,1.10,61809.5,.48,heavy

Each database injury was initially created in ORCA, using the penetration insult. The insult parameters (penetrator type, entry and exit point, etc.) were input manually into ORCA and the insults were processed. The resulting ORCA injuries were then analyzed to determine which category of the injury scenario they fell into (light, medium, or heavy). State categories for the bloodloss scenario were determined based on the blood loss rate. Although the database contains only one entry for the pneumothorax scenario, similar methodology could be applied to it, using the values for lung capacity. After the injuries were categorized, ORCA output data was translated into object names and attribute values and appropriately stored in the database. The OBC/Object Name Table at Appendix B served as the translation document.

The first database field corresponds to ECC Weapon Code. ECC Weapon Code 27 depicts the bloodloss scenario entries, while code 24 denotes gunshot wound (pneumothorax) injuries. Appendix D contains a complete listing of the database entries. The weapon code is followed by a corresponding DEPMEDS patient condition code, then a series of damaged objects. The list of damaged objects (corresponding to damaged body parts) is followed by the extent of damage done to each. The final five entries are lung capacity (cc), blood loss rate (liters/min), max AIS code (MAIS), probability of survival, and state (light, moderate, or heavy). A negative number for any field represents no data for that field, as is the case for lung capacity in the above example.

4.1.2 The Test

It is important to note that the Jackson Medical Scenario Library (JMSL) breaks down each scenario (bloodloss, pneumothorax, etc.) into eleven states. These states are based on the length of time the scenario has been running. For the test, it was necessary to artificially expand the injury database, using the data already present, to include an entry for each of the 11 JMSL states (0-10). This expanded database, containing 22 states, is located at Appendix E. The ORCA RTI interface read from the database and printed the resulting injury profile to the screen, as depicted in Figure 7.

state_number 8

CASUALTY CHARACTERISTICS:

Weapon Type :	27
Patient Condition code :19	
Skin_NFS:	2.40
FaceNFS:	<.20
SubcutaneousTissue:	1.35
HeadNeckNFS:	.20-.50
ExternalMaxillaryL:	>.50
AnteriorFacialL:	>.50
InternalJugularL:	>.50
Lung Capacity :	-1
Blood Loss Rate :	.33
MAX AIS Code :	40505.4
Probability of Survival: .90	
JMSL STATE :	7

Figure 7: Example Patient Injury Profile from CTPS Test Run

Note that the last entry in Figure 7 (JMSL STATE) corresponds to the one of eleven states. The ORCA RTI interface code randomly selects from the available states for a particular scenario, once the scenario is chosen. For the test, sufficient scenarios were not run to ensure that all 22 JMSL states were selected (11 for each scenario). Redundant state selection based on the inherent randomness made that a tedious and unnecessary option. Instead, enough scenarios were run to ensure that each of the original injury profile database data sets was represented (three variations for bloodloss and one for gunshot wound/pneumothorax). Also, the number of scenarios was sufficient to ensure that the output accurately represented the ORCA RTI interfaces ability to randomly select from a large database of injury types. This is evidenced through examination of the "JMSL STATE" number. Due to the artificial nature of the expanded test injury database, the state number is the key that differentiates otherwise identical data sets. Appendix F contains output data for patients injured through reading from the injury database.

The research carried out the test only this far, based on the aforementioned FOM immaturity. The definition of test success was demonstration of an ORCA RTI interface that could read values from the injury database, keep them matched to their respective objects, and display the objects with their corresponding values. If the ORCA RTI interface can read, store, and print the data from the injury database, then it logically follows that further manipulation is possible.

The ORCA RTI read, stored, and printed data from the database without error. The test was a success, proving that the concept of enhancing CTPS injuries through database retrieval is sound. A major finding of the test was that the current CTPS FOM is not robust enough to manifest symptoms of virtual patients afflicted with ORCA-generated injuries.

4.2 CTPS Phase III Version 0 FOM

As previously mentioned the MYSTECH FOM offers an excellent base for expansion. What follows is a description of research to integrate the previously developed Injury SOM into the MYSTECH FOM. On the following page, Table 5 depicts the methodology for integrating components of the Injury SOM into the Mystech FOM.

It is important to highlight a few things, in order to explain the rationale behind building the FOM in the manner described in Table 5. “Skin” and “Bone” are treated differently than “Striated Muscle.” The former two were added as subclasses under “Organ”, while the latter was added to the tissue groups for each body region. This was done mainly because of the way Mystech defined the various tissue groups. The tissue groups were defined by the main artery that supplies oxygenated blood to the specified region of the body. When muscles are traumatically damaged, there is often a significant amount of dead (due to lack of oxygen) muscle tissue that must be cut away through a process known as wound debridement. Discolored muscle tissue is cut away, exposing blood red, freshly oxygenated tissue.

Bones and skin also receive and rely on an oxygenated blood supply. However, the ORCA definition of skin did not allow for breaking it down into the various regions and the bone’s reliance on oxygenated blood was not seen as significant enough to warrant the structural break out.

Blood vessel • added to existing Mystech structure, under "cardiovascular ductwork"	Bone • added as subclass to Mystech's "organs" class	Lung lobe • added as subclass to Mystech's "lungs" class
Hollow organ – hard • added as subclass to Mystech's "organs" class	Hollow organ – soft • added as subclass to Mystech's "organs" class	Skin • added as subclass to Mystech's "organs" class
Striated Muscle • added as subclasses (by body region) to Mystech's "tissue groups" class	Nerve • added to existing Mystech structure, under "nervous ductwork"	
Solid Organ • added as subclass to Mystech's "organs" class	Go- no go • added as subclass (OtherMiscOrg) under Mystech's "organs" class	

Table 5: Injury SOM Integration Into Mystech FOM

The resulting FOM is located at Appendix G. This FOM accounts for all components of the Injury SOM, while leaving in tact most of the superb structure originally conceived by Mystech. This FOM, if used by the CTPS federation, would allow for detailed total body injury representation. This detailed anatomical account of injuries, made possible by ORCA, would be of great significance when considering the addition of visually oriented simulations to the CTPS federation. Current plans call for use of this FOM in Phase III of the CTPS program.

CHAPTER 5

5.1 Conclusion

ORCA is capable of producing injury profiles in conjunction with the ECC. ORCA injury profiles add more anatomical specificity to DEPMEDS codes, as well as increasing the variety of available injury types. Associating DEPMEDS codes with an ECC injury type provides universally recognized patient conditions. Creating an ORCA injury profile database increases the number of injuries in the available injury pool, while adding more anatomical specificity to the injuries. The successful testing, conducted as part of this research, demonstrated the capability of transferring data, through the RTI, from a prototype ORCA injury database. A major finding of the test was that the current CTPS FOM is inadequate for handling the enhanced injury profiles and a situation-based FOM will not suit long term use. Automation of the proposed injury generation methodology will provide quick, on-line access to this pool of realistic combat trauma injuries.

The current ORCA Alpha + version lacks the robustness to handle all injury types that the CTPS can handle. ORCA is fine for modeling injuries that require damage to tissue. ORCA does not do well modeling injury scenarios where the injury manifests itself solely as a change to human physiological parameters such as respiratory rate, heart rate, and blood pressure. Examples of these injuries include those depicted in the Phase I and II CTPS anaphylactic shock scenarios, as well as theoretical chemical/biological scenarios. Although ORCA does include a limited toxic substance insult, conversion of the output data into something useful by HPS would require significant work and medical expertise.

Conversely, the CTPS is not currently designed to sufficiently handle all of the possible ORCA output. Conversion functions may be necessary to convert the ORCA attributes of blood loss rate and lung capacity to something useable by the HPS. Also, the HPS lacks the capability to display the visual enhancements offered by ORCA's detail on injury location and size. Future research is needed to identify suitable visual enhancement technology, if the CTPS is ever to be used as a trainer for initial assessment of battlefield injuries.

Of the available insult types in the current ORCA version, the ORCA penetration insult model shows the most promise for providing CTPS injury generation, because it is capable of producing combat trauma type injuries to any portion of the human body. ORCA body components may be objectified and placed in an Injury SOM, along with potential ORCA-generated attributes. Potential attributes output from a penetration injury are: 1) damage to the affected OBCs; 2) initial blood loss rate; 3) blood loss to onset of shock; 4) percentage of lung volume lost and; 4) AIS code (body region/organ affected/level of injury based on anatomy/severity). The blast insult produces similar output, but it is limited to lung and ear injuries.

Work should continue on enhancing the CTPS Phase III Version 0 FOM. Mystech provided an excellent base FOM, however, realistic simulation of damage to human tissue, as with ORCA, must include the stimuli necessary to do the damage. Such an effort must also include the anatomical and physiological structure necessary for "total body" representation. Incorporation of the ORCA-derived Injury SOM into the Mystech FOM provided the additional necessary anatomy, as well as damage mechanisms required to identify the various "tissue damage" stimuli. However, tissue damage will trigger complex systemic interactions, the modeling of which are beyond the scope of this research and will require significant medical expertise, primarily in the areas of human anatomy and pathophysiological response.

5.2 Recommendations for Future Research

ORCA is capable of producing injury profiles that add more anatomical specificity to DEPMEDS codes, as well as increasing the variety of available injury types. Creating an ORCA injury profile database increases the number of injuries in the available injury pool, while adding more anatomical specificity to the injuries. Automation will provide quick, on-line access to this pool of realistic combat trauma injuries. However, when it comes to manifestation of these realistic injuries onto the HPS, it is important to note a few shortfalls in the current CTPS FOM. Discussion of possible CTPS FOM improvements follows.

CHAPTER 6

6.1 Visual Limitations of CTPS

The current CTPS has some limitations. One limitation is the inability to visually manifest the physical damage that occurs with a physical injury. According to Satava and Jones (1997b), " "Realism" is the prime determinant of believability in any virtual environment, with the medical arena having a high priority on realism" (p. 141). With this in mind, an ideal *virtual patient*, from a medical caregiver standpoint, should look and function much like a real patient on the outside and inside.

The current HPS can be "made-up" with moulage to add an element of realism through visual representation of external injuries. The drawback to this method is that it requires defiling the mannequin. It also means that someone must clean up the mess and change it before beginning a new scenario. Suggestions for CTPS enhancement have included the addition of an on screen virtual patient in close proximity to the HPS, as well as projection (from an external source) of injuries directly onto the mannequin.

The first CTPS enhancement suggestion would probably utilize some existing simulation that possesses the capability to take a set of injury parameters and display them appropriately (and realistically) onto a screen. The unfortunate thing about computer graphic representations is that they are usually easily identifiable as computer graphic representations. Unlike digital pictures or video, computer renderings often take on the appearance of a cartoon, limiting the ability of an application to portray a realistic virtual scene.

Many recent technological advances have brought us closer to the creation of the ideal virtual patient:

- the Visible Human Project has made it possible to view a realistic digital 3D representation of the human body, inside and out
- algorithms for stitching together digital images into panoramic scenes are now faster and more efficient
- visualization of virtual worlds through head mounted displays is better than ever
- tactile devices, such as the Phantom, have made it possible to realistically touch and manipulate objects in a virtual world

The projector-based CTPS enhancement suggestion, although simple and cheap, would most probably suffer from lack of quality, due to environmental factors such as lighting and patient movement.

6.2 Visually-Oriented Medical Simulations

There are a number of simulations currently available that are attempting to take advantage of the above technological trends. None, however, have attempted to join an HLA Federation such as the CTPS Federation. This research has already mentioned two simulators, MediSim (Stansfield et al., 1998) (a prototype) and the Virtual Medical Trainer – Trauma Patient Simulator (VMET-TPS) (RTI, 1998).

MediSim, developed by Sandia National Laboratories, focuses on situational training of first-line battlefield medical personnel whose responsibility it is to triage and stabilize multiple casualties, prior to their evacuation to field hospitals. This focus differentiates MediSim from some other VR-based medical trainers, whose primary goal is to train a specific procedure or task. MediSim's goal is to train rapid situational assessment and decision-making under battlefield conditions. MediSim's initial training procedure is the primary assessment. This first stage of triage is carried out for all wound types. Primary assessment involves evaluating each of the following in this order: airway, breathing, circulation, disability and expose. The procedure for each of these contains a number of steps used to diagnose and stabilize the casualty. It is important to note that "expose" is a visual check for wounds on the body; a procedure requiring a highly visible and realistically portrayed casualty.

VMET-TPS (formerly called VMT) is an interactive, multimedia, virtual- reality-based simulator that presents the user with a three-dimensional (3D) trauma scenario, complete with realistic visual and aural effects. The casualty is a 3D virtual model with realistic visual injuries and internal trauma. Injury mechanisms currently available include falls, gunshot wounds, vehicle collisions, explosions, and blunt injury. Similar to MediSim, VMET-TPS is an excellent initial assessment tool, allowing the user to enter and "size-up" the scene, determine level of consciousness, and attend to major life-threatening conditions. Many of these conditions present themselves visually (e.g. major hemorrhage).

6.3 The Need for Further Expansion of the MYSTECH FOM

Mystech's decision to limit the scope of the Physiological SOM to the cardiovascular and respiratory systems is based on these systems' key role in the intake and distribution of oxygen, a function key to survival of the physiological system. There is no denying the validity of this decision. However, not all simulations will rely so heavily on the underlying physiology. For instance, MediSim or the VMT-TPS are heavily dependent on visual information pertaining to the state of the human body. Information which might be derived from a baseball-sized hole being blown through the human chest region. This information can only be realistically rendered and updated with precise physical anatomical information.

The tissue damage provided by ORCA-generated injuries certainly calls for an additional stimulus to the Mystech Stimuli SOM and subsequent addition to the FOM. A "Damage to Tissue" stimulus seems in order. This particular stimulus type could be represented, for instance, one per ORCA Vulnerability Category, with a corresponding array of targeted objects (e.g. bone, muscle, blood vessels). Addition of the Injury SOM classes and attributes to the Mystech FOM is a good start, but the complex systemic interactions to the pathologic ORCA stimuli will also have to be dealt with and this will require a great deal of medical expertise.

Concerning the virtual patient, there should remain a healthy balance between anatomy, physiology, and pathophysiology, just as there is in the real human patient. The inherent synergism can not be ignored in the endeavor to create the perfect virtual patient model. Future research is needed to flush out the details of a CTPS FOM to support the virtual patient.

Appendix A

ORCA Penetration Insult Output

Appendix A – ORCA Output File Formats

A.1 - Penetration Injury to Thigh With Bleeding

```
winterm
Skin (NFS)                                 1.50 cm^2 damaged

Subcutaneous Tissue                        1.50 cm^2 damaged

Muscle (quadriceps femoris), L           Less than 20% damage

Femur, L                                 Comminuted Fracture

Muscle (abductor longus), L              Less than 20% damage

Artery (primary perforating)             50% or more laceration

Muscle (abductor magnus), L              Less than 20% damage

Subcutaneous Tissue
Muscle (biceps femoris), L               Less than 20% damage

Subcutaneous Tissue

Bleeding Process:

Number of Wounds = 1
Wound 1: Organ type: Peripheral Artery  Size: 0.25

Initial Rate = 0.15 liters/min
Shock Volume = 2.31 liters

Final Statistics:
Time to Cessation of Bleeding: 25.3
Blood Loss:   2.2
Residual Capability Factors:
        Immediate:         1.00
30 Seconds:        0.90
5 Minutes:         0.80
1 Hour:            0.37
24 Hours:          0.37
72 hours:          0.37

No Respiration Process


No Sepsis Process
```

A.2 – AIS and Survival Probability

```
winterm
Raw AIS   AIS Body Region             AIS Severity
-------   ---------------------------  ------------
10503.2   External                    Moderate
10303.2   External                    Moderate
92101.2   Lower Extremity             Moderate
90605.2   Lower Extremity             Moderate

Survival Probability (using ISS) =  0.989
```

Appendix B

OBC/Object Name Table

OBC #	ORCA Common Name	Object Name
88	head of femur,L	HeadOfFemurL
361	head of femur,R	HeadOfFemurR
99	ilium,L	IliumL
372	ilium,R	IliumR
86	Bone (ischium), L	IschiumL
360	Bone (ischium), R	IschiumR
84	Bone (pubis)	Pubis
82	Bone (wing of ilium), L	WingOfIliumL
359	Bone (wing of ilium), R	WingOfIliumR
127	Carpal Bones, L	CarpalBonesL
396	Carpal Bones, R	CarpalBonesR
37	Clavicle, L	ClavicleL
348	Clavicle, R	ClavicleR
80	Coccyx	Coccyx
330	Facial bone (mandibular ramus), R	MandibularRamusR
81	Facial Bone (mandible), L	MandibleL
358	Facial Bone (mandible), R	MandibleR
90	Facial Bone (mandibular body)	MandibularBody
8	Facial Bone (mandibular ramus), L	MandibularRamusL
66	Facial Bone (maxilla), L	MaxillaL
357	Facial Bone (maxilla), R	MaxillaR
42	Facial Bone (nasal)	Nasal
18	Facial Bone (zygoma), L	ZygomaL
334	Facial Bone (zygoma), R	ZygomaR
139	Femur, L	FemurL
408	Femur, R	FemurR
153	Fibula, L	FibulaL
419	Fibula, R	FibulaR
43	Humerus (proximal shaft), L	HumerusProxShaftL
351	Humerus (proximal shaft), R	HumerusProxShaftR
103	Humerus, L	HumerusL
377	Humerus, R	HumerusR
179	Hyloid Bone	Hyoid
161	Lateral and Medial Malleolus, L	LatMedMalleolusL
425	Lateral and Medial Malleolus, R	LatMedMalleolusR
133	Metacarpal Bones, L	MetacarpalBonesL
398	Metacarpal Bones, R	MetacarpalBonesR
171	Metatarsal Bones, L	MetatarsalBonesL
430	Metatarsal Bones, R	MetatarsalBonesR
141	Patella, L	PatellaL
409	Patella, R	PatellaR
172	Phalanges (foot), L	PhalangesFootL
431	Phalanges (foot), R	PhalangesFootR
135	Phalanges (hand), L	PhalangesHandL
400	Phalanges (hand), R	PhalangesHandR

115	Radius, L	RadiusL
390	Radius, R	RadiusR
45	Rib	Rib
78	Sacrum	Sacrum
180	Sacrum (near cauda equina)	SacrumCaudaEquina
39	Scapula, L	ScapulaL
349	Scapula, R	ScapulaR
41	Shoulder Joint, L	ShoulderJointL
350	Shoulder Joint, R	ShoulderJointR
4	Skull (base)	SkullBase
5	Skull (vault)	SkullVault
53	Sternum	Sternum
165	Tarsal Bones, L	TarsalBonesL
428	Tarsal Bones, R	TarsalBonesR
34	Thyroid (cartilage)	ThyroidCartilage
151	Tibia, L	TibiaL
418	Tibia, R	TibiaR
116	Ulna, L	UlnaL
391	Ulna, R	UlnaR
182	Vertebra (c1-c4 body)	VertebraC1_C4Body
190	Vertebra (c5-c7 body)	VertebraC5_C7Body
30	Vertebra (cervical odontoid)	VertCervicalOdontoid
131	Vertebra (cervical pedicle)	VertCervicalPedicle
174	Vertebra (cervical transverse)	VertCervicalTransverse
15	Vertebra (cervical)	VertebraCervical
67	Vertebra (lumbar body)	VertebraLumbarBody
146	Vertebra (lumbar lamina)	VertLumbarLamina
150	Vertebra (lumbar pedicle)	VertLumbarPedicle
65	Vertebra (lumbar spinal process)	VertLumbarSpinalProc
68	Vertebra (lumbar transverse)	VertLumbarTransverse
17	Vertebra (thoracic body)	VertThoracicBody
142	Vertebra (thoracic lamina)	VertThoracicLamina
32	Vertebra (thoracic pedicle)	VertThoracicPedicle
29	Vertebra (thoracic spinal process)	VertThoracicSpinProc
31	Vertebra (thoracic transverse)	VertThoracicTrans
71	Aorta (abdominal)	Abdominal
97	Aorta (thoracic)	Thoracic
173	Artery (jejunal)	Jejunal
220	Artery (anterior tibial), L	AnteriorTibialArtL
449	Artery (anterior tibial), R	AnteriorTibialArtR
239	Artery (arciformis)	Arciformis
216	Artery (axillary), L	AxillaryArtL
445	Artery (axillary), R	AxillaryArtR
114	Artery (basilar)	Basilar
290	Artery (brachial)	BrachialArt
124	Artery (circumflex coronary)	CircumflexCoronary

279	Artery (circumflex femoral), L	CircumflexFemoralL
458	Artery (circumflex femoral), R	CircumflexFemoralR
248	Artery (colic)	ColicArt
211	Artery (common carotid), L	CommonCarotidL
441	Artery (common carotid), R	CommonCarotidR
254	Artery (common iliac), L	CommonIliacL
454	Artery (common iliac), R	CommonIliacR
237	Artery (coronary)	Coronary
291	Artery (deep brachial)	DeepBrachial
429	Artery (deep cervical), R	DeepCervicalR
167	Artery (deep cervical), L	DeepCervicalL
145	Artery (deep femoral), L	DeepFemoralL
412	Artery (deep femoral), R	DeepFemoralR
134	Artery (digital), L	DigitalL
399	Artery (digital), R	DigitalR
184	Artery (external carotid), L	ExternalCarotidL
432	Artery (external carotid), R	ExternalCarotidR
262	Artery (external iliac)	ExternalIliacArt
285	Artery (external maxillary), L	ExternalMaxillaryL
460	Artery (external maxillary), R	ExternalMaxillaryR
143	Artery (femoral), L	FemoralArtL
410	Artery (femoral), R	FemoralArtR
228	Artery (gastric)	Gastric
242	Artery (gastroduodenal)	Gastroduodenal
274	Artery (gluteal), L	GlutealArtL
456	Artery (gluteal), R	GlutealArtR
263	Artery (hypogastric)	HypogastricArt
168	Artery (ileocolic)	IleocolicArt
96	Artery (iliac), L	IliacL
370	Artery (iliac), R	IliacR
255	Artery (iliolumbalis)	Iliolumbalis
264	Artery (inferior epigastric)	InferiorEpigastric
251	Artery (inferior mesenteric)	InferiorMesenteric
73	Artery (inferior phrenic)	InferiorPhrenic
205	Artery (inferior thyroid)	InferiorThyroid
275	Artery (inferior vesicular)	InferiorVesicular
217	Artery (innominate), L	InnominateL
446	Artery (innominate), R	InnominateR
223	Artery (intercostal)	Intercostal
21	Artery (internal carotid), L	InternalCarotidL
335	Artery (internal carotid), R	InternalCarotidR
209	Artery (internal mammary)	InternalMammary
112	Artery (interosseus), L	InterosseusL
382	Artery (interosseus), R	InterosseusR
119	Artery (left ant. des. coronary)	LeftAntDesCoronary
295	Artery (medial collateral), L	MedialCollateralL

466	Artery (medial collateral), R	MedialCollateralR
281	Artery (middle cerebral), L	MiddleCerebralL
459	Artery (middle cerebral), R	MiddleCerebralR
282	Artery (middle meningeal)	MiddleMeningeal
176	Artery (obturator)	ObturatorArt
25	Artery (occipital), L	OccipitalL
338	Artery (occipital), R	OccipitalR
245	Artery (pancreatic duodenal)	PancreaticDuodenal
178	Artery (peroneal), L	PeronealArtL
473	Artery (peroneal), R	PeronealArtR
148	Artery (popliteal), L	PoplitealArtL
414	Artery (popliteal), R	PoplitealArtR
200	Artery (posterior communicating), L	PostCommunicatingL
438	Artery (posterior communicating), R	PostCommunicatingR
214	Artery (posterior tibial), L	PosteriorTibialArtL
443	Artery (posterior tibial), R	PosteriorTibialArtR
278	Artery (primary perforating)	PrimaryPerforatingArt
276	Artery (pudendal)	Pudendal
222	Artery (pulmonary), L	PulmonaryL
451	Artery (pulmonary), R	PulmonaryR
293	Artery (radial collateral), L	RadialCollateralL
464	Artery (radial collateral), R	RadialCollateralR
117	Artery (radial), L	RadialArtL
392	Artery (radial), R	RadialArtR
109	Artery (recurrent radial), L	RecurrentRadialL
381	Artery (recurrent radial), R	RecurrentRadialR
106	Artery (recurrent ulnar), L	RecurrentUlnarL
379	Artery (recurrent ulnar), R	RecurrentUlnarR
236	Artery (renal), L	RenalArtL
453	Artery (renal), R	RenalArtR
125	Artery (right coronary)	RightCoronary
260	Artery (spermatic)	SpermaticArt
232	Artery (splenic)	SplenicArt
210	Artery (subclavian), L	SubclavianArtL
440	Artery (subclavian), R	SubclavianArtR
22	Artery (superficial temporal), L	SuperficialTemporalL
336	Artery (superficial temporal), R	SuperficialTemporalR
199	Artery (superior cerebral), L	SuperiorCerebralArtL
437	Artery (superior cerebral), R	SuperiorCerebralArtR
243	Artery (superior mesenteric)	SuperiorMesentericArt
294	Artery (ulnar collateral), L	UlnarCollateralL
465	Artery (ulnar collateral), R	UlnarCollateralR
121	Artery (ulnar), L	UlnarArtL
394	Artery (ulnar), R	UlnarArtR
203	Artery (vertebral)	VertebralArt
224	Thoracic Duct	ThoracicDuct

177	Vein (angular)	Angular
420	Vein (anterior tibial), R	AnteriorTibialVeinR
286	Vein (anterior facial), L	AnteriorFacialL
461	Vein (anterior facial), R	AnteriorFacialR
201	Vein (anterior jugular), L	AnteriorJugularL
439	Vein (anterior jugular), R	AnteriorJugularR
155	Vein (anterior tibial), L	AnteriorTibialVeinL
54	Vein (axillary), L	AxillaryVeinL
354	Vein (axillary), R	AxillaryVeinR
204	Vein (azygos)	AzygosVein
108	Vein (basilic)	Basilic
213	Vein (brachial), L	BrachialVeinL
442	Vein (brachial), R	BrachialVeinR
107	Vein (cephalic), L	CephalicL
380	Vein (cephalic), R	CephalicR
163	Vein (colic)	ColicVein
289	Vein (common facial), L	CommonFacialL
462	Vein (common facial), R	CommonFacialR
164	Vein (common iliac), L	CommonIliacL
427	Vein (common iliac), R	CommonIliacR
288	Vein (communicans)	Communicans
284	Vein (deep cervical)	Deepcervical
159	Vein (deep femoral), L	DeepFemoralL
423	Vein (deep femoral), R	DeepFemoralR
269	Vein (external iliac)	ExternalIliacVein
51	Vein (external jugular), L	ExternalJugularL
353	Vein (external jugular), R	ExternalJugularR
144	Vein (femoral), L	FemoralVeinL
411	Vein (femoral), R	FemoralVeinR
170	Vein (gluteal)	GlutealVein
234	Vein (hemizygos)	Hemizygos
72	Vein (hepatic)	Hepatic
265	Vein (hypogastric)	HypogastricVein
256	Vein (ileocolic)	IleocolicVein
169	Vein (inferior epigastric)	InferiorEpigastric
249	Vein (inferior mesenteric)	InferiorMesenteric
74	Vein (inferior vena cava)	InferiorVenaCava
218	Vein (innominate), L	InnominateL
447	Vein (innominate), R	InnominateR
185	Vein (internal jugular), L	InternalJugularL
433	Vein (internal jugular), R	InternalJugularR
208	Vein (intervertebral)	Intervertebral
252	Vein (intestinal)	Intestinal
175	Vein (middle cerebral)	MiddleCerebral
273	Vein (obturator)	ObturatorVein
156	Vein (peroneal), L	PeronealVeinL

472	Vein (peroneal), R	PeronealVeinR
158	Vein (popliteal), L	PoplitealVeinL
422	Vein (popliteal), R	PoplitealVeinR
195	Vein (portal)	Portal
287	Vein (posterior facial)	PosteriorFacial
421	Vein (posterior tibial), R	PosteriorTibialVeinR
181	Vein (primary perforating)	PrimaryPerforatingVein
221	Vein (pulmonary), L	PulmonaryVeinsL
450	Vein (pulmonary), R	PulmonaryVeinsR
120	Vein (radial), L	RadialVeinL
393	Vein (radial), R	RadialVeinR
233	Vein (renal), L	RenalVeinL
452	Vein (renal), R	RenalVeinR
147	Vein (saphenous), L	SaphenousVeinL
413	Vein (saphenous), R	SaphenousVeinR
250	Vein (spermatic)	SpermaticVein
231	Vein (splenic)	SplenicVein
448	Vein (subclavian), R	SubclavianVeinR
219	Vein (subclavian),L	SubclavianVeinL
198	Vein (superior cerebral), L	SuperiorCerebralVeinL
436	Vein (superior cerebral), R	SuperiorCerebralVeinR
247	Vein (superior mesenteric)	SuperiorMesentericVein
52	Vein (superior vena cava)	SuperiorVenaCava
122	Vein (ulnar), L	UlnarVeinL
395	Vein (ulnar), R	UlnarVeinR
162	Vein (variant), L	VariantL
426	Vein (variant), R	VariantR
240	Vein (vertebral venus plexus)	VertebralVenusPlexus
207	Vein (vertebral)	VertebralVein
157	Vein posterior tibial), L	PosteriorTibialVeinL
186	Ear (internal), L	InternalL
434	Ear (internal), R	InternalR
24	Retina, L	RetinaL
337	Retina, R	RetinaR
62	Adrenals	Adrenals
244	Bile Duct	BileDuct
10	Eye, L (except eyeball & sclera)	EyeLNoEyeballSclera
332	Eye, R (except eyeball and sclera)	EyeRNoEyeballSclera
241	Gall Bladder (c and h duct)	GallBladderCHDuct
50	Heart (chambers & valves)	HeartChambersValves
55	Heart Valves	HeartValves
94	Penis	Penis
118	Pituitary	Pituitary
277	Seminal Vesicle (testicle), L	SeminalVesicleL
457	Seminal Vesicle (testicle), R	SeminalVesicleR
20	Superior Sagittal Sinus	SuperiorSagittalSinus

16	Thyroid Gland	Thyroid
64	Ureter, L	UreterL
356	Ureter, R	UreterR
197	Urethra	Urethra
206	Bronchus	Bronchus
14	Larynx	Larynx
13	Pharynx	Pharynx
35	Trachea	Trachea
189	Duodenum	Duodenum
36	Esophagus	Esophagus
59	Gall Bladder	GallBladder
126	Heart (left atrium)	AtriaLeft
130	Heart (left ventricle)	VentricleLeft
128	Heart (right atrium)	AtriaRight
129	Heart (right ventricle)	VentricleRight
57	Large Intestine	LargeIntestine
253	Mesentery	Mesentery
61	Pancreas	Pancreas
225	Pericardium	Pericardium
111	Pleura	Pleura
191	Rectum	Rectum
238	Small Intestine	SmallIntestine
56	Stomach	Stomach
93	Urinary Bladder	Urinary Bladder
91	Lung (inferior lobe), L	InferiorLobeL
362	Lung (inferior lobe), R	InferiorLobeR
95	Lung (middle lobe)	MiddleLobe
47	Lung (superior lobe), L	LungSuperiorLobeL
352	Lung (superior lobe), R	LungSuperiorLobeR
166	Adductor Brevis, L	AdductorBrevisL
366	Adductor Brevis, R	AdductorBrevisR
321	Adductor Longus, L	AdductorLongusL
367	Adductor Longus, R	AdductorLongusR
188	Adductor Magnus, L	AdductorMagnusL
368	Adductor Magnus, R	AdductorMagnusR
85	Biceps Brachii, L	BicepsBrachiiL
374	Biceps Brachii, R	BicepsBrachiiR
303	Biceps Femoris, L	BicepsFemorisL
402	Biceps Femoris, R	BicepsFemorisR
152	Buccinator	Buccinator
314	Deltoid, L	DeltoidL
342	Deltoid, R	DeltoidR
48	Diaphragm L&R	DiaphragmLR
301	Extensor Carpi Radialis Longus, L	ExtCarpiRadLongusL
388	Extensor Carpi Radialis Longus, R	ExtCarpiRadLongusR
320	Extensor Digitorum, L	ExtensorDigitorumL

387	Extensor Digitorum, R	ExtensorDigitorumR
280	Flexor Carpi Ulnaris, L	FlexorCarpiUlnarisL
386	Flexor Carpi Ulnaris, R	FlexorCarpiUlnarisR
230	Flexor Digitorum Superficialus, L	FlexorDigitSuperficL
385	Flexor Digitorum Superficialus, R	FlexorDigitSuperficR
307	Gastrocnemius, L	GastrocnemiusL
416	Gastrocnemius, R	GastrocnemiusR
227	Gluteus Maximus, L	GluteusMaximusL
364	Gluteus Maximus, R	GluteusMaximusR
318	Gluteus Medius, L	GluteusMediusL
363	Gluteus Medius, R	GluteusMediusR
193	Gracilus, L	GracilusL
369	Gracilus, R	GracilusR
49	Heart (epicardium & myocardium)	HeartEpicardMyocard
299	Iliocostalis	Iliocostalis
300	Iliopsoas	Iliopsoas
315	Infraspinatus, L	InfraspinatusL
344	Infraspinatus, R	InfraspinatusR
311	Latissimus Dorsi, L	LatissimusDorsiL
339	Latissimus Dorsi, R	LatissimusDorsiR
298	Longissimus	Longissimus
154	Masseter	Masseter
160	Muscle (foot), L	FootL
424	Muscle (foot), R	FootR
310	Muscle (sartorious), L	SartoriousL
468	Muscle (sartorious), R	SartoriousR
309	Muscle (semispinalis group)	SemispinalisGroup
123	Muscle (wrist)	WristL
470	Muscle (wrist), R	WristR
70	Muscle, abdomen, NFS	AbdomenNFS
113	Muscle, Forearm NFS, L	ForearmNFS_L
383	Muscle, Forearm, NFS, R	ForearmNFS_R
11	Muscle, head & neck, NFS	HeadNeckNFS
149	Muscle, Lower Leg, NFS, L	LowerLegNFS_L
415	Muscle, Lower Leg, NFS, R	LowerLegNFS_R
92	Muscle, Pelvis, NFS	PelvisNFS
26	Muscle, thorax, NFS	ThoraxNFS
373	Muscle, Upper Arm, NFS, R	UpperArmNFS_R
101	Muscle, Upper Arm, NFS,L	UpperArmNFS_L
136	Muscle, Upper Leg, NFS, L	UpperLegNFS_L
401	Muscle, Upper Leg, NFS, R	UpperLegNFS_R
7	Muscle,face, NFS	FaceNFS
104	Obicularis oris	ObicularisOris
319	Pectinius, L	PectiniusL
365	Pectinius, R	PectiniusR
312	Pectoralis Major, L	PectoralisMajorL

340	Pectoralis Major, R	PectoralisMajorR
313	Pectoralis Minor, L	PectoralisMinorL
341	Pectoralis Minor, R	PectoralisMinorR
196	Pronator Quadratus, L	PronatorQuadratusL
384	Pronator Quadratus, R	PronatorQuadratusR
306	Quadriceps Femoris, L	QuadricepsFemorisL
405	Quadriceps Femoris, R	QuadricepsFemorisR
77	Rectus Abdominus	RectusAbdominus
304	Semimembranosus, L	SemimembranosusL
403	Semimembranosus, R	SemimembranosusR
305	Semitendinosus, L	SemitendinosusL
404	Semitendinosus, R	SemitendinosusR
132	Soft Tissue (hand), L	SoftTissueHandL
397	Soft Tissue (hand), R	SoftTissueHandR
297	Spinalis	Spinalis
235	Splenius	Splenius
246	Sternocleidomastoid	Sternocleidomastoid
317	Subscapularis, L	SubscapularisL
346	Subscapularis, R	SubscapularisR
271	Supraspinatus, L	SupraspinatusL
343	Supraspinatus, R	SupraspinatusR
226	Temporalis	Temporalis
316	Teres Minor, L	TeresMinorL
345	Teres Minor, R	TeresMinorR
302	Thenar Eminence, L	ThenarEminenceL
389	Thenar Eminence, R	ThenarEminenceR
308	Tibialis Anterior, L	TibialisAnteriorL
417	Tibialis Anterior, R	TibialisAnteriorR
283	Tongue	Tongue
257	Trapezius, L	TrapeziusL
333	Trapezius, R	TrapeziusR
87	Triceps Brachii, L	TricepsBrachiiL
375	Triceps Brachii, R	TricepsBrachiiR
23	Brain (frontal lobe)	BrainFrontalLobe
6	Brain (minus frontal lobe)	BrainNoFrontalLobe
183	Brain Stem	BrainStem
69	Cauda Equina	CaudaEquina
202	Nerve (acoustic)	Acoustic
28	Nerve (brachialplexus), L	BrachialplexusL
347	Nerve (brachialplexus), R	BrachialplexusR
212	Nerve (cranial)	Cranial
138	Nerve (femoral), L	FemoralNVL
407	Nerve (femoral), R	FemoralNVR
267	Nerve (First Sacral)	FirstSacral
259	Nerve (lumbar)	Lumbar
266	Nerve (lumbosacral trunk)	LumbosacralTrunk

292	Nerve (median), L	MedianL
463	Nerve (median), R	MedianR
102	Nerve (musculocutaneous), L	MusculocutaneousL
376	Nerve (musculocutaneous), R	MusculocutaneousR
258	Nerve (obturator)	ObturatorNV
194	Nerve (peroneal), L	PeronealNVL
471	Nerve (peroneal), R	PeronealNVR
27	Nerve (phrenic)	PhrenicNV
296	Nerve (radial), L	RadialNVL
467	Nerve (radial), R	RadialNVR
261	Nerve (sacral)	Sacral
98	Nerve (saphenous), L	SaphenousNVL
371	Nerve (saphenous), R	SaphenousNVR
137	Nerve (sciatic), L	SciaticL
406	Nerve (sciatic), R	SciaticR
268	Nerve (Second sacral)	SecondSacral
270	Nerve (Third sacral)	ThirdSacral
192	Nerve (tibial), L	TibialL
435	Nerve (tibial), R	TibialR
215	Nerve (ulnar), L	UlnarNVL
444	Nerve (ulnar), R	UlnarNVR
187	Nerve (vagus)	VagusNV
12	Nerve, cervical	Cervical
9	Optic Nerve, L	OpticNerveL
331	Optic nerve, R	OpticNerveR
19	Spinal Cord (C1-C3)	SpinalCordC1_C3
110	Spinal Cord (C4-C7)	SpinalCordC4_C7
76	Spinal Cord (L1-L2)	SpinalCordL1_L2
33	Spinal Cord (T1-T12)	SpinalCordT1_T12
1	Skin, NFS	Skin_NFS
378	Ear (external), R	EarExternalR
105	Ear external, L	EarExternalL
3	Scalp	Scalp
329	Skin - sole of foot-R	SoleOfFootR
38	Skin-Elbow, antecubital area-L	ElbowAntecubitalL
322	Skin-Elbow, antecubital area-R	ElbowAntecubitalR
40	Skin-Elbow, olecranon area-L	ElbowOlecranonL
323	Skin-Elbow, olecranon area-R	ElbowOlecranonR
140	Skin-Foot and ankle (not sole)-L	FootAnkleNoSoleL
328	Skin-Foot and ankle (not sole)-R	FootAnkleNoSoleR
79	Skin-Hand, dorsal surface, L	HandDorsalSurfaceL
326	Skin-Hand, dorsal surface-R	HandDorsalSurfaceR
83	Skin-Hand, volar surface-L	HandVolarSurfaceL
327	Skin-hand, volar surface-R	HandVolarSurfaceR
44	Skin-Knee, patellar area-L	KneePatellarL
324	Skin-Knee, patellar area-R	KneePatellarR

46	Skin-Knee, popliteal area-L	KneePoplitealL
325	Skin-Knee, popliteal area-R	KneePoplitealR
100	Skin-Periorbital area	Periorbital
89	Skin-Sole of foot-L	SoleOfFootL
2	Subcutaneous Tissue	SubcutaneousTissue
63	Kidney, L	KidneyL
355	Kidney, R	KidneyR
58	Liver	Liver
272	Meniscus (tibial), L	MeniscusTibialL
455	Meniscus (tibial), R	MeniscusTibialR
60	Spleen	Spleen
75	Vertebra (cervical lamina)	CervicalLamina

Appendix C

Injury SOM

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Class1	Class2	Class3	Class4
Casualty (PS)	Nerve (N)	BrainFrontalLobe (PS)	
		BrainNoFrontalLobe (PS)	
		BrainStem (PS)	
		CaudaEquina (PS)	
		VagusNV (PS)	
		SpinalColumn (PS)	SpinalCordC1_C3 (PS)
			SpinalCordC4_C7 (PS)
			SpinalCordL1_L2 (PS)
			SpinalCordT1_T12 (PS)
		Acoustic (PS)	
		BrachialplexusL (PS)	
		BrachialplexusR (PS)	
		Cranial (PS)	
		FemoralNVL (PS)	
		FemoralNVR (PS)	
		FirstSacral (PS)	
		Lumbar (PS)	
		LumbosacralTrunk (PS)	
		MedianL (PS)	
		MedianR (PS)	
		MusculocutaneousL (PS)	
		MusculocutaneousR (PS)	
		ObturatorNV (PS)	
		PeronealNVL (PS)	
		PeronealNVR (PS)	
		RadialNVL (PS)	
		RadialNVR (PS)	
		Sacral (PS)	
		SaphenousNVL (PS)	
		SaphenousNVR (PS)	
		SciaticL (PS)	
		SciaticR (PS)	
		SecondSacral (PS)	
		ThirdSacral (PS)	
		TibialL (PS)	
		TibialR (PS)	
		UlnarNVL (PS)	
		UlnarNVR (PS)	
		Cervical (PS)	
		OpticNerveL (PS)	
		OpticNerveR (PS)	
	HollowOrganHard (N)	Pharynx (PS)	

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Class1	Class2	Class3	Class4
		Larynx (PS)	
		Trachea (PS)	
		Bronchia (PS)	
	BloodVessel (N)	Artery (N)	ExternalIliacArt (PS)
			HypogastricArt (PS)
			IliacArtR (PS)
			IliacArtL (PS)
			AbdomParietArtL (PS)
			AbdomParietArtR (PS)
			AbdomViscArtL (PS)
			AbdomViscArtR (PS)
			IntercostalArt (PS)
			Jejunal (PS)
			AnteriorTibialArtL (PS)
			AnteriorTibialArtR (PS)
			Arciformis (PS)
			AxillaryArtL (PS)
			AxillaryArtR (PS)
			Basilar (PS)
			BrachialArt (PS)
			CircumflexFemoralL (PS)
			CircumflexFemoralR (PS)
			ColicArt (PS)
			DeepBrachial (PS)
			DeepCervicalL (PS)
			DeepCervicalR (PS)
			DeepFemoralL (PS)
			DeepFemoralR (PS)
			DigitalL (PS)
			DigitalR (PS)
			ExternalCarotidL (PS)
			ExternalCarotidR (PS)
			CircumflexCoronary (PS)
			ExternalMaxillaryL (PS)
			ExternalMaxillaryR (PS)
			FemoralArtL (PS)
			FemoralArtR (PS)
			Gastric (PS)
			Gastroduodenal (PS)
			GlutealArtL (PS)
			GlutealArtR (PS)
			IleocolicArt (PS)

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Class1	Class2	Class3	Class4
			Iliolumbalis (PS)
			InferiorEpigastric (PS)
			InferiorMesenteric (PS)
			InferiorThyroid (PS)
			InferiorVesicular (PS)
			InternalCarotidL (PS)
			InternalCarotidR (PS)
			InnominateL (PS)
			InnominateR (PS)
			InternalMammary (PS)
			InterosseusL (PS)
			InterosseusR (PS)
			MedialCollateralL (PS)
			MedialCollateralR (PS)
			MiddleCerebralL (PS)
			MiddleCerebralR (PS)
			MiddleMeningeal (PS)
			ObturatorArt (PS)
			OccipitalL (PS)
			OccipitalR (PS)
			PancreaticDuodenal (PS)
			PeronealArtL (PS)
			PeronealArtR (PS)
			PoplitealArtL (PS)
			PoplitealArtR (PS)
			PostCommunicatingL (PS)
			PostCommunicatingR (PS)
			PosteriorTibialArtL (PS)
			PosteriorTibialArtR (PS)
			PrimaryPerforatingArt (PS)
			Pudendal (PS)
			RadialCollateralL (PS)
			RadialCollateralR (PS)
			RadialArtL (PS)
			RadialArtR (PS)
			RecurrentRadialL (PS)
			RecurrentRadialR (PS)
			RecurrentUlnarL (PS)
			RecurrentUlnarR (PS)
			SpermaticArt (PS)
			SplenicArt (PS)
			SuperficialTemporalL (PS)

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Class1	Class2	Class3	Class4
			SuperficialTemporalR (PS)
			SuperiorCerebralArtL (PS)
			SuperiorCerebralArtR (PS)
			SuperiorMesentericArt (PS)
			UlnarCollateralL (PS)
			UlnarCollateralR (PS)
			UlnarArtL (PS)
			UlnarArtR (PS)
			VertebralArt (PS)
			RenalArtL (PS)
			RenalArtR (PS)
		Aorta (N)	Abdominal (PS)
			Thoracic (PS)
		Vein (N)	HypogastricVein (PS)
			ExternalIliacVein (PS)
			SuperiorVenaCava (PS)
			InferiorVenaCava (PS)
			AzygosVein (PS)
			SubclavianVeinR (PS)
			SubclavianVeinL (PS)
			PulmonaryVeinsR (PS)
			PulmonaryVeinsL (PS)
			CoronaryVeinR (PS)
			CoronaryVeinL (PS)
			Angular (PS)
			AnteriorTibialVeinL (PS)
			AnteriorTibialVeinR (PS)
			AnteriorFacialL (PS)
			AnteriorFacialR (PS)
			AxillaryVeinL (PS)
			AxillaryVeinR (PS)
			Basilic (PS)
			BrachialVeinL (PS)
			BrachialVeinR (PS)
			CephalicL (PS)
			CephalicR (PS)
			ColicVein (PS)
			CommonFacialL (PS)
			CommonFacialR (PS)
			CommonIliacL (PS)
			CommonIliacR (PS)
			Communicans (PS)

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Class1	Class2	Class3	Class4
			Deepcervical (PS)
			DeepFemoralL (PS)
			DeepFemoralR (PS)
			ExternalJugularR (PS)
			ExternalJugularL (PS)
			FemoralVeinL (PS)
			FemoralVeinR (PS)
			GlutealVein (PS)
			Hemizygos (PS)
			Hepatic (PS)
			IleocolicVein (PS)
			InferiorEpigastric (PS)
			InferiorMesenteric (PS)
			InternalJugularR (PS)
			InternalJugularL (PS)
			Intervertebral (PS)
			Intestinal (PS)
			MiddleCerebral (PS)
			ObturatorVein (PS)
			PeronealVeinL (PS)
			PeronealVeinR (PS)
			PoplitealVeinL (PS)
			PoplitealVeinR (PS)
			PosteriorFacial (PS)
			PosteriorTibialVeinL (PS)
			PosteriorTibialVeinR (PS)
			PrimaryPerforatingVein (PS)
			RadialVeinL (PS)
			RadialVeinR (PS)
			RenalVeinL (PS)
			RenalVeinR (PS)
			SaphenousVeinL (PS)
			SaphenousVeinR (PS)
			SpermaticVein (PS)
			SplenicVein (PS)
			SuperiorCerebralVeinL (PS)
			SuperiorCerebralVeinR (PS)
			SuperiorMesentericVein (PS)
			UlnarVeinL (PS)
			UlnarVeinR (PS)
			VariantL (PS)
			VariantR (PS)

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Class1	Class2	Class3	Class4
			VertebralVenusPlexus (PS)
			VertebralVein (PS)
		Duct (N)	ThoracicDuct (PS)
	Lungs (PS)	InferiorLobeL (PS)	
		InferiorLobeR (PS)	
		MiddleLobe (PS)	
		SuperiorLobeL (PS)	
		SuperiorLobeR (PS)	
	Muscle (N)	BicepsBrachiiL (PS)	
		BicepsBrachiiR (PS)	
		DeltoidL (PS)	
		DeltoidR (PS)	
		ExtCarpiRadLongusL (PS)	
		ExtCarpiRadLongusR (PS)	
		ExtensorDigitorumL (PS)	
		ExtensorDigitorumR (PS)	
		FlexorCarpiUlnarisL (PS)	
		FlexorCarpiUlnarisR (PS)	
		FlexorDigitSuperficL (PS)	
		FlexorDigitSuperficR (PS)	
		WristL (PS)	
		WristR (PS)	
		ForearmNFS_L (PS)	
		ForearmNFS_R (PS)	
		UpperArmNFS_L (PS)	
		UpperArmNFS_R (PS)	
		PectoralisMajorL (PS)	
		PectoralisMajorR (PS)	
		PectoralisMinorL (PS)	
		PectoralisMinorR (PS)	
		SoftTissueHandL (PS)	
		SoftTissueHandR (PS)	
		SubscapularisL (PS)	
		SubscapularisR (PS)	
		SupraspinatusL (PS)	
		SupraspinatusR (PS)	
		TeresMinorL (PS)	
		TeresMinorR (PS)	
		TricepsBrachiiL (PS)	
		TricepsBrachiiR (PS)	
		InfraspinatusL (PS)	
		InfraspinatusR (PS)	

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Class1	Class2	Class3	Class4
		ThenarEminenceL (PS)	
		ThenarEminenceR (PS)	
		AdductorBrevisL (PS)	
		AdductorBrevisR (PS)	
		AdductorLongusL (PS)	
		AdductorLongusR (PS)	
		AdductorMagnusL (PS)	
		AdductorMagnusR (PS)	
		BicepsFemorisL (PS)	
		BicepsFemorisR (PS)	
		GastrocnemiusL (PS)	
		GastrocnemiusR (PS)	
		GluteusMaximusL (PS)	
		GluteusMaximusR (PS)	
		GluteusMediusL (PS)	
		GluteusMediusR (PS)	
		GracilusL (PS)	
		GracilusR (PS)	
		Iliopsoas (PS)	
		FootL (PS)	
		FootR (PS)	
		SartoriousL (PS)	
		SartoriousR (PS)	
		LowerLegNFS_L (PS)	
		LowerLegNFS_R (PS)	
		PectiniusL (PS)	
		PectiniusR (PS)	
		PronatorQuadratusL (PS)	
		PronatorQuadratusR (PS)	
		QuadricepsFemorisL (PS)	
		QuadricepsFemorisR (PS)	
		SemimembranosusL (PS)	
		SemimembranosusR (PS)	
		SemitendinosusL (PS)	
		SemitendinosusR (PS)	
		TibialisAnteriorL (PS)	
		TibialisAnteriorR (PS)	
		Abdominal (PS)	
		ExternalIntercostals (PS)	
		InternalIntercostals (PS)	
		Diaphragm (PS)	
		ThoraxNFS (PS)	

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Class1	Class2	Class3	Class4
		Buccinator (PS)	
		Masseter (PS)	
		SemispinalisGroup (PS)	
		NeadNeckNFS (PS)	
		FaceNFS (PS)	
		ObicularisOris (PS)	
		Sternocleidomastoid (PS)	
		Temporalis (PS)	
		Tongue (PS)	
		TrapeziusL (PS)	
		TrapeziusR (PS)	
		LatissimusDorsiL (PS)	
		LatissimusDorsiR (PS)	
		Longissimus (PS)	
		Spinalis (PS)	
		Splenius (PS)	
		AbdomenNFS (PS)	
		RectusAbdominus (PS)	
		PelvisNFS (PS)	
		HeartEpicardMyocard (PS)	
	Bone (PS)	HeadOfFemurL (PS)	
		HeadOfFemurR (PS)	
		IliumL (PS)	
		IliumR (PS)	
		IschiumL (PS)	
		IschiumR (PS)	
		Pubis (PS)	
		WingOfIliumL (PS)	
		WingOfIliumR (PS)	
		CarpalBonesL (PS)	
		CarpalBonesR (PS)	
		ClavicleL (PS)	
		ClavicleR (PS)	
		Coccyx (PS)	
		MandibularRamusR (PS)	
		MandibleL (PS)	
		MandibleR (PS)	
		MandibularBody (PS)	
		MandibularRamusL (PS)	
		MaxillaL (PS)	
		MaxillaR (PS)	
		Nasal (PS)	

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(Injury SOM)

Class1	Class2	Class3	Class4
		ZygomaL (PS)	
		ZygomaR (PS)	
		FemurL (PS)	
		FemurR (PS)	
		FibulaL (PS)	
		FibulaR (PS)	
		HumerusProxShaftL (PS)	
		HumerusProxShaftR (PS)	
		HumerusL (PS)	
		HumerusR (PS)	
		Hyoid (PS)	
		LatMedMalleolusL (PS)	
		LatMedMalleolusR (PS)	
		MetacarpalBonesL (PS)	
		MetacarpalBonesR (PS)	
		MetatarsalBonesL (PS)	
		MetatarsalBonesR (PS)	
		PatellaL (PS)	
		PatellaR (PS)	
		PhalangesFootL (PS)	
		PhalangesFootR (PS)	
		PhalangesHandL (PS)	
		PhalangesHandR (PS)	
		RadiusL (PS)	
		RadiusR (PS)	
		Rib (PS)	
		Sacrum (PS)	
		SacrumCaudaEquina (PS)	
		ScapulaL (PS)	
		ScapulaR (PS)	
		ShoulderJointL (PS)	
		ShoulderJointR (PS)	
		SkullBase (PS)	
		SkullVault (PS)	
		Sternum (PS)	
		TarsalBonesL (PS)	
		TarsalBonesR (PS)	
		ThyroidCartilage (PS)	
		TibiaL (PS)	
		TibiaR (PS)	
		UlnaL (PS)	
		UlnaR (PS)	

Appendix C
(Injury SOM)

Class1	Class2	Class3	Class4
		VertebraC1_C4Body (PS)	
		VertebraC5_C7Body (PS)	
		VertCervicalOdontoid (PS)	
		VertCervicalPedicle (PS)	
		VertCervicalTransverse (PS)	
		VertebraCervical (PS)	
		VertebraLumbarBody (PS)	
		VertLumbarLamina (PS)	
		VertLumbarPedicle (PS)	
		VertLumbarSpinalProc (PS)	
		VertLumbarTransverse (PS)	
		VertThoracicBody (PS)	
		VertThoracicLamina (PS)	
		VertThoracicPedicle (PS)	
		VertThoracicSpinProc (PS)	
		VertThoracicTrans (PS)	
	Ear (N)	InternalL (PS)	
		InternalR (PS)	
	Eye (N)	RetinaL (PS)	
		RetinaR (PS)	
	Skin (N)	Skin_NFS (PS)	
		EarExternalL (PS)	
		EarExternalR (PS)	
		Scalp (PS)	
		SoleOfFootR (PS)	
		ElbowAntecubitalL (PS)	
		ElbowAntecubitalR (PS)	
		ElbowOlecranonL (PS)	
		ElbowOlecranonR (PS)	
		FootAnkleNoSoleL (PS)	
		FootAnkleNoSoleR (PS)	
		HandDorsalSurfaceL (PS)	
		HandDorsalSurfaceR (PS)	
		HandVolarSurfaceL (PS)	
		HandVolarSurfaceR (PS)	
		KneePatellarL (PS)	
		KneePatellarR (PS)	
		KneePoplitealL (PS)	
		KneePoplitealR (PS)	
		Periorbital (PS)	
		SoleOfFootL (PS)	
		SubcutaneousTissue (PS)	

Appendix C
(Injury SOM)

Class1	Class2	Class3	Class4
	Other (N)	HeartValves (PS)	
		EyeLNoEyeballSclera (PS)	
		EyeRNoEyeballSclera (PS)	
		Penis (PS)	
		SeminalVesicleL (PS)	
		SeminalVesicleR (PS)	
		BileDuct (PS)	
		UreterL (PS)	
		UreterR (PS)	
		Urethra (PS)	
		GallBladderCHDuct (PS)	
		SuperiorSagittalSinus (PS)	
		Adrenals (PS)	
		Pituitary (PS)	
		Thyroid (PS)	
		HeartChambersValves (PS)	
	HollowOrganSoft (N)	Pericardium (PS)	
		Duodenum (PS)	
		LargeIntestine (PS)	
		Mesentery (PS)	
		SmallIntestine (PS)	
		Pleura (PS)	
		GallBladder (PS)	
		Pancreas (PS)	
		Rectum (PS)	
		Stomach (PS)	
		VentricleLeft (PS)	
		VentricleRight (PS)	
		AtriaLeft (PS)	
		AtriaRight (PS)	
		UrinaryBladder (PS)	
		Esophagus (PS)	
	SolidOrgan (N)	KidneyL (PS)	
		KidneyR (PS)	
		Liver (PS)	
		Spleen (PS)	
		MeniscusTibialL (PS)	
		MeniscusTibialR (PS)	
		CervicalLamina (PS)	

Object	Attribute	Datatype	Cardinality	Units	Resolution
BloodVessel	BVDamage	string	1		
Bone	BoneDamage	string	1		
Casualty	BloodLossRate	short	1		
	SurvivalProb	unsigned short	1	percentage	
	MaxAISCode	string	1		
Ear	EarDamage	string	1		
Eye	EyeDamage	string	1		
HollowOrganHard	HOHDamage	string	1		
HollowOrganSoft	HOSDamage	string	1		
Lungs	LungDamage	unsigned short	1	percentage	
Muscle	MuscleDamage	string	1		
Nerve	NerveDamage	string	1		
Other	OtherDamage	string	1		
Skin	SkinDamage	float	1	cm2	hundredths
SolidOrgan	SODamage	string	1		

Appendix C
(Injury SOM)
Attribute Table

Accuracy	Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Conditional		N	UR
perfect	always	Static		N	UR
perfect	always	Conditional		N	UR
perfect	always	Periodic		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR
perfect	always	Static		N	UR

Appendix C
(Injury SOM)
Attribute Table

Routing Space
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A

Appendix C
(Injury SOM)
Attribute Table

Appendix D

Prototype Injury Profile Database

Appendix D – Prototype Injury Profile Database

CTPS - Prototype Injury Profile Database - Version 0 - Created by CPT Greg Creech - 16 Nov 98

Narrative Description. This database was created using injury data from ORCA. The intent was to create a database using ORCA injury data as a baseline for mapping the injury to other injury categorization and generation mechanisms or scenarios (e.g. ECC, DEPMEDS, JMSL). Two CTPS Phase I injury types were used for ECC mapping. These were Bloodloss and Gunshot Wound Causing Pneumothorax. ORCA to ECC mapping portrays three variations of Bloodloss and one Gunshot Wound Causing Pneumothorax, although many more variations are possible.

Database Structure. The injury profiles are listed in linear format, with values for each field separated by a comma. Each injury profile is separated by a space. For each injury profile database line read: ECC Weapon Type, DEPMEDS Patient Condition Code, Damaged Objects*, Damage Done**, Lung Capacity, Blood Loss Rate, Max AIS Code (MAIS), Probability of Survival, and JMSL State. Numbers greater than 1 but less than 1000 are in square centimeters, with the exception of blood loss rate, which is in liters per minute and lung damage, which is in cc and is labeled as such. The AIS Code consists of five digits, followed by a decimal point and one digit. Numbers less than one but greater than zero represent a percentage. Some percentage values are represented as greater than a certain percentage, some as less than, and some have a range (e.g. >.30, <.50, or .20-.40). Decreasing ranges for lung capacity represent a decrease in lung capacity from time zero to 5 minutes. A negative number entry for any field represents no data for that field.

*Note: When ORCA generates injuries, the output comes in the form of common names for the specific ORCA Body Components (OBC) damaged. These were translated into object names for each OBC. The database contains the object names. This field (and the corresponding damage done field, are the only text fields in the database. Also, they are the only fields with multiple entries. The number of entries (injured objects) will vary by injury type. For future reference, I will provide a separate Excel file which lists OBC #, common name, and object name.
**Note: These entries relate one-to-one to the previously listed object names.

END OF NARRATIVE

#Bloodloss
27,176,Skin_NFS,SubcutaneousTissue,AbdomenNFS,Liver,KidneyR,UreterR,RenalR,Longissimus,.36,1.60,<.20,fracture>.50,fracture>.50,damage,>.50,<.20,-1,1.10,61809.5,.48,heavy

27,19,Skin_NFS,FaceNFS,SubcutaneousTissue,HeadNeckNFS,ExternalMaxillaryL,AnteriorFacialL,InternalJugularL,2.40,<.20,1.35,.20-.50,>.50,>.50,>.50,-1,.33,40505.4,.90,moderate

27,131,Skin_NFS,SubcutaneousTissue,MetatarsalBonesL,TibialisAnteriorL,LowerLegNFS_L,PeronealL,GastrocnemiusL,1.69,2.37,comminuted fracture,>.80,.20-.50,>.50laceration,<.20,-1,.12,90605.2,.99,light

#Gunshot Wound Pneumothorax
24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97

Appendix E

Expanded Test Injury Profile Database

Appendix E – Expanded Test Injury Profile Database

#Bloodloss
27,176,Skin_NFS,SubcutaneousTissue,AbdomenNFS,Liver,KidneyR,UreterR,RenalR,Lo
ngissimus,.36,1.60,<.20,fracture>.50,fracture>.50,damage,>.50,<.20,-
1,1.10,61809.5,.48,0

27,19,Skin_NFS,FaceNFS,SubcutaneousTissue,HeadNeckNFS,ExternalMaxillaryL,Ante
riorFacialL,InternalJugularL,2.40,<.20,1.35,.20-.50,>.50,>.50,>.50,-1,.33,40505.4,.90,1

27,131,Skin_NFS,SubcutaneousTissue,MetatarsalBonesL,TibialisAnteriorL,LowerLegN
FS_L,PeronealL,GastrocnemiusL,1.69,2.37,comminuted fracture,>.80,.20-
.50,>.50laceration,<.20,-1,.12,90605.2,.99,2

27,176,Skin_NFS,SubcutaneousTissue,AbdomenNFS,Liver,KidneyR,UreterR,RenalR,Lo
ngissimus,.36,1.60,<.20,fracture>.50,fracture>.50,damage,>.50,<.20,-
1,1.10,61809.5,.48,3

27,19,Skin_NFS,FaceNFS,SubcutaneousTissue,HeadNeckNFS,ExternalMaxillaryL,Ante
riorFacialL,InternalJugularL,2.40,<.20,1.35,.20-.50,>.50,>.50,>.50,-1,.33,40505.4,.90,4

27,131,Skin_NFS,SubcutaneousTissue,MetatarsalBonesL,TibialisAnteriorL,LowerLegN
FS_L,PeronealL,GastrocnemiusL,1.69,2.37,comminuted fracture,>.80,.20-
.50,>.50laceration,<.20,-1,.12,90605.2,.99,5

27,176,Skin_NFS,SubcutaneousTissue,AbdomenNFS,Liver,KidneyR,UreterR,RenalR,Lo
ngissimus,.36,1.60,<.20,fracture>.50,fracture>.50,damage,>.50,<.20,-
1,1.10,61809.5,.48,6

27,19,Skin_NFS,FaceNFS,SubcutaneousTissue,HeadNeckNFS,ExternalMaxillaryL,Ante
riorFacialL,InternalJugularL,2.40,<.20,1.35,.20-.50,>.50,>.50,>.50,-1,.33,40505.4,.90,7

27,131,Skin_NFS,SubcutaneousTissue,MetatarsalBonesL,TibialisAnteriorL,LowerLegN
FS_L,PeronealL,GastrocnemiusL,1.69,2.37,comminuted fracture,>.80,.20-
.50,>.50laceration,<.20,-1,.12,90605.2,.99,8

27,176,Skin_NFS,SubcutaneousTissue,AbdomenNFS,Liver,KidneyR,UreterR,RenalR,Lo
ngissimus,.36,1.60,<.20,fracture>.50,fracture>.50,damage,>.50,<.20,-
1,1.10,61809.5,.48,9

27,19,Skin_NFS,FaceNFS,SubcutaneousTissue,HeadNeckNFS,ExternalMaxillaryL,Ante
riorFacialL,InternalJugularL,2.40,<.20,1.35,.20-.50,>.50,>.50,>.50,-1,.33,40505.4,.90,10

#Gunshot Wound Pneumothorax

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,0

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,1

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,2

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,3

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,4

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,5

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,6

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,7

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,8

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,9

24,88,Skin_NFS,PectoralisMajorR,ThoraxNFS,Rib,SubcutaneousTissue,MiddleLobe,Pleura,4.19,.20-.50,<.20,punchout,9.35,63.80cc,>.50,.8-.4,-1,50104.3,.97,10

Appendix F

Patient Injury Data from CTPS Test Runs

Appendix F – Patient Injury Data from CTPS Test Runs

----

state_number 7

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 6

----

state_number 10

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 9

---

state_number 1

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 0

---

state_number 11

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :19
Skin_NFS: 2.40
FaceNFS: <.20
SubcutaneousTissue: 1.35
HeadNeckNFS: .20-.50
ExternalMaxillaryL: >.50
AnteriorFacialL: >.50
InternalJugularL: >.50
Lung Capacity : -1
Blood Loss Rate : .33
MAX AIS Code : 40505.4
Probability of Survival: .90
JMSL STATE : 10

----

state_number 8

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :19
Skin_NFS: 2.40
FaceNFS: <.20
SubcutaneousTissue: 1.35
HeadNeckNFS: .20-.50
ExternalMaxillaryL: >.50
AnteriorFacialL: >.50
InternalJugularL: >.50
Lung Capacity : -1
Blood Loss Rate : .33
MAX AIS Code : 40505.4
Probability of Survival: .90
JMSL STATE : 7

----

state_number 10

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 9

----

state_number 3

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :131
Skin_NFS: 1.69
SubcutaneousTissue: 2.37
MetatarsalBonesL: comminuted fracture
TibialisAnteriorL: >.80
LowerLegNFS_L: .20-.50
PeronealL: >.50laceration
GastrocnemiusL: <.20
Lung Capacity : -1
Blood Loss Rate : .12
MAX AIS Code : 90605.2
Probability of Survival: .99
JMSL STATE : 2

----

state_number 10

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 9

----

state_number 9

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :131
Skin_NFS: 1.69
SubcutaneousTissue: 2.37
MetatarsalBonesL: comminuted fracture
TibialisAnteriorL: >.80
LowerLegNFS_L: .20-.50
PeronealL: >.50laceration
GastrocnemiusL: <.20
Lung Capacity : -1
Blood Loss Rate : .12
MAX AIS Code : 90605.2
Probability of Survival: .99
JMSL STATE : 8

----

state_number 6

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :131
Skin_NFS: 1.69
SubcutaneousTissue: 2.37
MetatarsalBonesL: comminuted fracture
TibialisAnteriorL: >.80
LowerLegNFS_L: .20-.50
PeronealL: >.50laceration
GastrocnemiusL: <.20
Lung Capacity : -1
Blood Loss Rate : .12
MAX AIS Code : 90605.2
Probability of Survival: .99
JMSL STATE : 5

---

state_number 10

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 9

---

state_number 2

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :19
Skin_NFS: 2.40
FaceNFS: <.20
SubcutaneousTissue: 1.35
HeadNeckNFS: .20-.50
ExternalMaxillaryL: >.50
AnteriorFacialL: >.50
InternalJugularL: >.50
Lung Capacity : -1
Blood Loss Rate : .33
MAX AIS Code : 40505.4
Probability of Survival: .90
JMSL STATE : 1

----

state_number 5

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :19
Skin_NFS: 2.40
FaceNFS: <.20
SubcutaneousTissue: 1.35
HeadNeckNFS: .20-.50
ExternalMaxillaryL: >.50
AnteriorFacialL: >.50
InternalJugularL: >.50
Lung Capacity : -1
Blood Loss Rate : .33
MAX AIS Code : 40505.4
Probability of Survival: .90
JMSL STATE : 4

----

state_number 1

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 0

----
state_number 1

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 0

----
state_number 7

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 6

----

state_number 6

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :131
Skin_NFS: 1.69
SubcutaneousTissue: 2.37
MetatarsalBonesL: comminuted fracture
TibialisAnteriorL: >.80
LowerLegNFS_L: .20-.50
PeronealL: >.50laceration
GastrocnemiusL: <.20
Lung Capacity : -1
Blood Loss Rate : .12
MAX AIS Code : 90605.2
Probability of Survival: .99
JMSL STATE : 5

----

state_number 1

CASUALTY CHARACTERISTICS:

Weapon Type : 27
Patient Condition code :176
Skin_NFS: .36
SubcutaneousTissue: 1.60
AbdomenNFS: <.20
Liver: fracture>.50
KidneyR: fracture>.50
UreterR: damage
RenalR: >.50
Longissimus: <.20
Lung Capacity : - 1
Blood Loss Rate : 1.10
MAX AIS Code : 61809.5
Probability of Survival: .48
JMSL STATE : 0

----

state_number 9

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 8

----

state_number 5

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 4

---

state_number 8

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 7

---

state_number 6

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 5

----

state_number 7

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 6

----

state_number 2

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 1

----

state_number 1

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 0

----

state_number 3

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 2

----

state_number 3

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 2

----

state_number 8

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 7

----

state_number 11

CASUALTY CHARACTERISTICS:

Weapon Type : 24
Patient Condition code :88
Skin_NFS: 4.19
PectoralisMajorR: .20-.50
ThoraxNFS: <.20
Rib: punchout
SubcutaneousTissue: 9.35
MiddleLobe: 63.80cc
Pleura: >.50
Lung Capacity : .8-.4
Blood Loss Rate : -1
MAX AIS Code : 50104.3
Probability of Survival: .97
JMSL STATE : 10

Appendix G

CTPS Phase III Version 0 FOM

Appendix G
CTPS Phase III
Version 0 FOM
Object Class
Structure Table

Class1	Class2	Class3	Class4	Class5
OrganicDuctwork (N)	NervousDuctwork (N)	SympAbdomViscNV (PS)		
		SympEsophgNV (PS)		
		SympCarotidNV (PS)		
		SympSubclavianNV (PS)		
		SympIntIlliacNV (PS)		
		SympExtIlliacNV (PS)		
		SympRenalNV (PS)		
		SympBronchialNV (PS)		
		SympatheticCardiacNerve (PS)		
		AbdominalNV (PS)		
		IntercostalNV (PS)		
		GlossopharyngealNV (PS)		
		PhrenicNV (PS)		
		VagusNV (PS)		
		SpinalColumn (PS)	SpinalCordC1_C3 (PS)	
			SpinalCordC4_C7 (PS)	
			SpinalCordL1_L2 (PS)	
			SpinalCordT1_T12 (PS)	
		Acoustic (PS)		
		BrachialplexusL (PS)		
		BrachialplexusR (PS)		
		Cranial (PS)		
		FemoralNVL (PS)		
		FemoralNVR (PS)		
		FirstSacral (PS)		
		Lumbar (PS)		
		LumbosacralTrunk (PS)		
		MedianL (PS)		
		MedianR (PS)		
		MusculocutaneousL (PS)		
		MusculocutaneousR (PS)		
		ObturatorNV (PS)		
		PeronealNVL (PS)		
		PeronealNVR (PS)		
		RadialNVL (PS)		
		RadialNVR (PS)		
		Sacral (PS)		
		SaphenousNVL (PS)		
		SaphenousNVR (PS)		
		SciaticL (PS)		
		SciaticR (PS)		
		SecondSacral (PS)		
		ThirdSacral (PS)		
		TibialL (PS)		

Appendix G
CTPS Phase III
Version 0 FOM
Object Class
Structure Table

Class1	Class2	Class3	Class4	Class5
		TibialR (PS)		
		UlnarNVL (PS)		
		UlnarNVR (PS)		
		Cervical (PS)		
		OpticNerveL (PS)		
		OpticNerveR (PS)		
	RespiratoryDuctwork (N)	Pharynx (PS)		
		Larynx (PS)		
		Trachea (PS)		
		Bronchia (PS)		
	CardiovascularDuctwork (N)	ArteryinBody (N)	ExternalIliacArt (PS)	ExternalIliacArtR (PS)
				ExternalIliacArtL (PS)
			HypogastricArt (PS)	InternalIliacArtR (PS)
				InternalIliacArtL (PS)
			IliacArtR (PS)	
			IliacArtL (PS)	
			AbdomParietArtL (PS)	
			AbdomParietArtR (PS)	
			AbdomViscArtL (PS)	
			AbdomViscArtR (PS)	
			RenalArt (PS)	RenalArtL (PS)
				RenalArtR (PS)
			EsophagealArt (PS)	
			IntercostalArt (PS)	
			BronchialArt (PS)	
			SuperiorPhrenicArt (PS)	
			SubclavianArtL (PS)	
			CommonCarotidArtL (PS)	
			SubclavianArtR (PS)	
			CommonCarotidArtR (PS)	
			BrachiocephalicArt (PS)	InnominateL (PS)
				InnominateR (PS)
			CoronaryArteryR (PS)	
			CoronaryArteryL (PS)	CircumflexCoronary (PS)
			PulmonaryArteryR (PS)	
			PulmonaryArteryL (PS)	
			PulmonaryTrunk (PS)	
			Jejunal (PS)	
			AnteriorTibialArtL (PS)	
			AnteriorTibialArtR (PS)	
			Arciformis (PS)	
			AxillaryArtL (PS)	
			AxillaryArtR (PS)	
			Basilar (PS)	

Class1	Class2	Class3	Class4	Class5
			Brachial (PS)	
			CircumflexFemoralL (PS)	
			CircumflexFemoralR (PS)	
			ColicArt (PS)	
			DeepBrachial (PS)	
			DeepCervicalL (PS)	
			DeepCervicalR (PS)	
			DeepFemoralL (PS)	
			DeepFemoralR (PS)	
			DigitalL (PS)	
			DigitalR (PS)	
			ExternalCarotidL (PS)	
			ExternalCarotidR (PS)	
			ExternalMaxillaryL (PS)	
			ExternalMaxillaryR (PS)	
			FemoralArtL (PS)	
			FemoralArtR (PS)	
			Gastric (PS)	
			Gastroduodenal (PS)	
			GlutealArtL (PS)	
			GlutealArtR (PS)	
			IleocolicArt (PS)	
			Iliolumbalis (PS)	
			InferiorEpigastric (PS)	
			InferiorMesenteric (PS)	
			InferiorThyroid (PS)	
			InferiorVesicular (PS)	
			InternalCarotidL (PS)	
			InternalCarotidR (PS)	
			InternalMammary (PS)	
			InterosseusL (PS)	
			InterosseusR (PS)	
			MedialCollateralL (PS)	
			MedialCollateralR (PS)	
			MiddleCerebralL (PS)	
			MiddleCerebralR (PS)	
			MiddleMeningeal (PS)	
			ObturatorArt (PS)	
			OccipitalL (PS)	
			OccipitalR (PS)	
			PancreaticDuodenal (PS)	
			PeronealArtL (PS)	
			PeronealArtR (PS)	
			PoplitealArtL (PS)	

Appendix G
CTPS Phase III
Version 0 FOM
Object Class
Structure Table

Class1	Class2	Class3	Class4	Class5
			PoplitealArtR (PS)	
			PostCommunicatingL (PS)	
			PostCommunicatingR (PS)	
			PosteriorTibialArtL (PS)	
			PosteriorTibialArtR (PS)	
			PrimaryPerforatingArt (PS)	
			Pudendal (PS)	
			RadialCollateralL (PS)	
			RadialCollateralR (PS)	
			RadialArtL (PS)	
			RadialArtR (PS)	
			RecurrentRadialL (PS)	
			RecurrentRadialR (PS)	
			RecurrentUlnarL (PS)	
			RecurrentUlnarR (PS)	
			SpermaticArt (PS)	
			SplenicArt (PS)	
			SuperficialTemporalL (PS)	
			SuperficialTemporalR (PS)	
			SuperiorCerebralArtL (PS)	
			SuperiorCerebralArtR (PS)	
			SuperiorMesentericArt (PS)	
			UlnarCollateralL (PS)	
			UlnarCollateralR (PS)	
			UlnarArtL (PS)	
			UlnarArtR (PS)	
			VertebralArt (PS)	
		Aorta (N)	DescendingAorta (PS)	
			AscendingAorta (PS)	
			AorticArch (PS)	
		VeininBody (N)	HypogastricVein (PS)	InternalIliacVeinR (PS)
				InternalIliacVeinL (PS)
			ExternalIliacVein (PS)	ExternalIliacVeinR (PS)
				ExternalIliacVeinL (PS)
			SuperiorVenaCava (PS)	
			InferiorVenaCava (PS)	
			RenalVein (PS)	RenalVeinL (PS)
				RenalVeinR (PS)
			PhrenicVein (PS)	
			HepaticPortalVein (PS)	
			AzygosVein (PS)	
			BrachiocephalicVeinR (PS)	
			BrachiocephalicVeinL (PS)	
			SubclavianVeinR (PS)	

Class1	Class2	Class3	Class4	Class5
			SubclavianVeinL (PS)	
			JugularVeinsR (PS)	AnteriorJugularR (PS)
				ExternalJugularR (PS)
				InternalJugularR (PS)
			JugularVeinsL (PS)	AnteriorJugularL (PS)
				ExternalJugularL (PS)
				InternalJugularL (PS)
			PulmonaryVeinsR (PS)	
			PulmonaryVeinsL (PS)	
			CoronaryVeinR (PS)	
			CoronaryVeinL (PS)	
			Angular (PS)	
			AnteriorTibialVeinL (PS)	
			AnteriorTibialVeinR (PS)	
			AnteriorFacialL (PS)	
			AnteriorFacialR (PS)	
			AxillaryVeinL (PS)	
			AxillaryVeinR (PS)	
			Basilic (PS)	
			BrachialVeinL (PS)	
			BrachialVeinR (PS)	
			CephalicL (PS)	
			CephalicR (PS)	
			ColicVein (PS)	
			CommonFacialL (PS)	
			CommonFacialR (PS)	
			CommonIliacL (PS)	
			CommonIliacR (PS)	
			Communicans (PS)	
			Deepcervical (PS)	
			DeepFemoralL (PS)	
			DeepFemoralR (PS)	
			FemoralVeinL (PS)	
			FemoralVeinR (PS)	
			GlutealVein (PS)	
			Hemizygos (PS)	
			Hepatic (PS)	
			IleocolicVein (PS)	
			InferiorEpigastric (PS)	
			InferiorMesenteric (PS)	
			Intervertebral (PS)	
			Intestinal (PS)	
			MiddleCerebral (PS)	
			ObturatorVein (PS)	

Class1	Class2	Class3	Class4	Class5
			PeronealVeinL (PS)	
			PeronealVeinR (PS)	
			PoplitealVeinL (PS)	
			PoplitealVeinR (PS)	
			PosteriorFacial (PS)	
			PosteriorTibialVeinL (PS)	
			PosteriorTibialVeinR (PS)	
			PrimaryPerforatingVein (PS)	
			RadialVeinL (PS)	
			RadialVeinR (PS)	
			SaphenousVeinL (PS)	
			SaphenousVeinR (PS)	
			SpermaticVein (PS)	
			SplenicVein (PS)	
			SuperiorCerebralVeinL (PS)	
			SuperiorCerebralVeinR (PS)	
			SuperiorMesentericVein (PS)	
			UlnarVeinL (PS)	
			UlnarVeinR (PS)	
			VariantL (PS)	
			VariantR (PS)	
			VertebralVenusPlexus (PS)	
			VertebralVein (PS)	
Organs (N)	Bone (PS)	HeadOfFemurL (PS)		
		HeadOfFemurR (PS)		
		IliumL (PS)		
		IliumR (PS)		
		IschiumL (PS)		
		IschiumR (PS)		
		Pubis (PS)		
		WingOfIliumL (PS)		
		WingOfIliumR (PS)		
		CarpalBonesL (PS)		
		CarpalBonesR (PS)		
		ClavicleL (PS)		
		ClavicleR (PS)		
		Coccyx (PS)		
		MandibularRamusR (PS)		
		MandibleL (PS)		
		MandibleR (PS)		
		MandibularBody (PS)		
		MandibularRamusL (PS)		
		MaxillaL (PS)		
		MaxillaR (PS)		

Class1	Class2	Class3	Class4	Class5
		Nasal (PS)		
		ZygomaL (PS)		
		ZygomaR (PS)		
		FemurL (PS)		
		FemurR (PS)		
		FibulaL (PS)		
		FibulaR (PS)		
		HumerusProxShaftL (PS)		
		HumerusProxShaftR (PS)		
		HumerusL (PS)		
		HumerusR (PS)		
		Hyoid (PS)		
		LatMedMalleolusL (PS)		
		LatMedMalleolusR (PS)		
		MetacarpalBonesL (PS)		
		MetacarpalBonesR (PS)		
		MetatarsalBonesL (PS)		
		MetatarsalBonesR (PS)		
		PatellaL (PS)		
		PatellaR (PS)		
		PhalangesFootL (PS)		
		PhalangesFootR (PS)		
		PhalangesHandL (PS)		
		PhalangesHandR (PS)		
		RadiusL (PS)		
		RadiusR (PS)		
		Rib (PS)		
		Sacrum (PS)		
		SacrumCaudaEquina (PS)		
		ScapulaL (PS)		
		ScapulaR (PS)		
		ShoulderJointL (PS)		
		ShoulderJointR (PS)		
		SkullBase (PS)		
		SkullVault (PS)		
		Sternum (PS)		
		TarsalBonesL (PS)		
		TarsalBonesR (PS)		
		ThyroidCartilage (PS)		
		TibiaL (PS)		
		TibiaR (PS)		
		UlnaL (PS)		
		UlnaR (PS)		
		VertebraC1_C4Body (PS)		

Class1	Class2	Class3	Class4	Class5
		VertebraC5_C7Body (PS)		
		VertCervicalOdontoid (PS)		
		VertCervicalPedicle (PS)		
		VertCervicalTransverse (PS)		
		VertebraCervical (PS)		
		VertebraLumbarBody (PS)		
		VertLumbarLamina (PS)		
		VertLumbarPedicle (PS)		
		VertLumbarSpinalProc (PS)		
		VertLumbarTransverse (PS)		
		VertThoracicBody (PS)		
		VertThoracicLamina (PS)		
		VertThoracicPedicle (PS)		
		VertThoracicSpinProc (PS)		
		VertThoracicTrans (PS)		
	Brain (PS)	BrainFrontalLobe (PS)		
		BrainNoFrontalLobe (PS)		
		BrainStem (PS)		
		CaudaEquina (PS)		
	Ear (N)	InternalL (PS)		
		InternalR (PS)		
	Eye (N)	RetinaL (PS)		
		RetinaR (PS)		
	Skin (N)	Skin_NFS (PS)		
		EarExternalL (PS)		
		EarExternalR (PS)		
		Scalp (PS)		
		SoleOfFootR (PS)		
		ElbowAntecubitalL (PS)		
		ElbowAntecubitalR (PS)		
		ElbowOlecranonL (PS)		
		ElbowOlecranonR (PS)		
		FootAnkleNoSoleL (PS)		
		FootAnkleNoSoleR (PS)		
		HandDorsalSurfaceL (PS)		
		HandDorsalSurfaceR (PS)		
		HandVolarSurfaceL (PS)		
		HandVolarSurfaceR (PS)		
		KneePatellarL (PS)		
		KneePatellarR (PS)		
		KneePoplitealL (PS)		
		KneePoplitealR (PS)		
		Periorbital (PS)		
		SoleOfFootL (PS)		

Class1	Class2	Class3	Class4	Class5
		SubcutaneousTissue (PS)		
	OtherMiscOrg (N)	EyeLNoEyeballSclera (PS)		
		EyeRNoEyeballSclera (PS)		
		Penis (PS)		
		SeminalVesicleL (PS)		
		SeminalVesicleR (PS)		
		Gland (N)	Adrenals (PS)	
			Pituitary (PS)	
			Thyroid (PS)	
		SuperiorSagittalSinus (PS)		
		OtherDuctwork (N)	ThoracicDuct (PS)	
			BileDuct (PS)	
			GallBladderCHDuct (PS)	
			UreterL (PS)	
			UreterR (PS)	
			Urethra (PS)	
		HeartChambersValves (PS)		
	HollowSoftOrgans (N)	Chambers (N)	HeartChambers (PS)	VentricleLeft (PS)
				VentricleRight (PS)
				AtriaLeft (PS)
				AtriaRight (PS)
		Duodenum (PS)		
		LargeIntestine (PS)		
		Mesentery (PS)		
		SmallIntestine (PS)		
		GallBladder (PS)		
		Pancreas (PS)		
		Rectum (PS)		
		Stomach (PS)		
		UrinaryBladder (PS)		
	OtherSolidOrgan (N)	Kidney (N)	KidneyL (PS)	
			KidneyR (PS)	
		Liver (PS)		
		Spleen (PS)		
		MeniscusTibialL (PS)		
		MeniscusTibialR (PS)		
		CervicalLamina (PS)		
	Heart (PS)	Pericardium (PS)		
	Lungs (PS)	InferiorLobeL (PS)		
		InferiorLobeR (PS)		
		MiddleLobe (PS)		
		SuperiorLobeL (PS)		
		SuperiorLobeR (PS)		
		Pleura (PS)		

Class1	Class2	Class3	Class4	Class5
OrganicRCPTRS (N)	ChemoReceptor (N)	CO2Sensor (N)	MedulCO2Recpt (PS)	
		PHSensor (N)	MedulPHRecpt (PS)	
		O2Sensor (N)	CarotO2Recpt (PS)	
			AorticO2Recpt (PS)	
	BaroReceptor (N)	BAROAorticArch (PS)		
		BAROCarotidSinus (PS)		
	IrritantSensor (N)	AveolarIrritantSensor (PS)		
		BronchioleIrritantSensor (PS)		
		LarynxIrritantSensor (PS)		
		TrachealIrritantSensor (PS)		
TissueGroups (N)	UpperLimbTissue (PS)	BicepsBrachiiL (PS)		
		BicepsBrachiiR (PS)		
		DeltoidL (PS)		
		DeltoidR (PS)		
		ExtCarpiRadLongusL (PS)		
		ExtCarpiRadLongusR (PS)		
		ExtensorDigitorumL (PS)		
		ExtensorDigitorumR (PS)		
		FlexorCarpiUlnarisL (PS)		
		FlexorCarpiUlnarisR (PS)		
		FlexorDigitSuperficL (PS)		
		FlexorDigitSuperficR (PS)		
		WristL (PS)		
		WristR (PS)		
		ForearmNFS_L (PS)		
		ForearmNFS_R (PS)		
		UpperArmNFS_L (PS)		
		UpperArmNFS_R (PS)		
		PectoralisMajorL (PS)		
		PectoralisMajorR (PS)		
		PectoralisMinorL (PS)		
		PectoralisMinorR (PS)		
		SoftTissueHandL (PS)		
		SoftTissueHandR (PS)		
		SubscapularisL (PS)		
		SubscapularisR (PS)		
		SupraspinatusL (PS)		
		SupraspinatusR (PS)		
		TeresMinorL (PS)		
		TeresMinorR (PS)		
		TricepsBrachiiL (PS)		
		TricepsBrachiiR (PS)		
		InfraspinatusL (PS)		
		InfraspinatusR (PS)		

Class1	Class2	Class3	Class4	Class5
		ThenarEminenceL (PS)		
		ThenarEminenceR (PS)		
	LowerLimbTissue (PS)	AdductorBrevisL (PS)		
		AdductorBrevisR (PS)		
		AdductorLongusL (PS)		
		AdductorLongusR (PS)		
		AdductorMagnusL (PS)		
		AdductorMagnusR (PS)		
		BicepsFemorisL (PS)		
		BicepsFemorisR (PS)		
		GastrocnemiusL (PS)		
		GastrocnemiusR (PS)		
		GluteusMaximusL (PS)		
		GluteusMaximusR (PS)		
		GluteusMediusL (PS)		
		GluteusMediusR (PS)		
		GracilusL (PS)		
		GracilusR (PS)		
		Iliopsoas (PS)		
		FootL (PS)		
		FootR (PS)		
		SartoriousL (PS)		
		SartoriousR (PS)		
		LowerLegNFS_L (PS)		
		LowerLegNFS_R (PS)		
		PectiniusL (PS)		
		PectiniusR (PS)		
		PronatorQuadratusL (PS)		
		PronatorQuadratusR (PS)		
		QuadricepsFemorisL (PS)		
		QuadricepsFemorisR (PS)		
		SemimembranosusL (PS)		
		SemimembranosusR (PS)		
		SemitendinosusL (PS)		
		SemitendinosusR (PS)		
		TibialisAnteriorL (PS)		
		TibialisAnteriorR (PS)		
	IntIliiacViscNParietTissue (PS	PelvisNFS (PS)		
	AbdomVisceraTissue (PS)			
	KidneyTissue (PS)			
	HeartTissue (PS)	HeartEpicardMyocard (PS)		
	EsophagusTissue (PS)	Esophagus (PS)		
	LungTissue (PS)			
	HeadAndNeck (PS)	Buccinator (PS)		

Appendix G
CTPS Phase III
Version 0 FOM
Object Class
Structure Table

Class1	Class2	Class3	Class4	Class5
		Masseter (PS)		
		SemispinalisGroup (PS)		
		NeadNeckNFS (PS)		
		FaceNFS (PS)		
		ObicularisOris (PS)		
		Sternocleidomastoid (PS)		
		Temporalis (PS)		
		Tongue (PS)		
		TrapeziusL (PS)		
		TrapeziusR (PS)		
	AbdomenAndBack (PS)	LatissimusDorsiL (PS)		
		LatissimusDorsiR (PS)		
		Longissimus (PS)		
		Spinalis (PS)		
		Splenius (PS)		
		AbdomenNFS (PS)		
		RectusAbdominus (PS)		
	RespiratoryMuscles (N)	Abdominal (PS)		
		ExternalIntercostals (PS)		
		InternalIntercostals (PS)		
		Diaphragm (PS)		
		ThoraxNFS (PS)		
Cavities (N)	NasalCavity (PS)			
	ThoracicCavity (PS)			
	PleuralCavity (PS)			
Valves (N)	HeartValves (N)	AorticSemiLunarValve (PS)		
		PulmonarySemiLunarValve (PS		
		MitralValve (PS)		
		TricuspidValve (PS)		
Epiglottis (PS)				
LumpedZones (N)	LungConductingZone (PS)			
	LungRespiratoryZone (PS)			
Human (PS)				
HeartChambers (N)	VentricleLeft (PS)			
	VentricleRight (PS)			
	AtriaLeft (PS)			
	AtriaRight (PS)			
CardiovascularSystem (S)				
RespiratorySystem (S)				
BodyEnvironMatrix (PS)				
airMixture (PS)				
smokeGasMixture (N)				
localParticleClusterCloud (N)				
localChemicalVaporCloud (N)				

Appendix G
CTPS Phase III
Version 0 FOM
Object Class
Structure Table

Class1	Class2	Class3	Class4	Class5
gas (N)	O2 (N)			
	CO2 (N)			
	CO (N)			
volatileChemicalVaporCloud (PS				
particleClusterCloud (PS)				
MedicalDrugs (N)	Methacholine (N)			
	Albuterol (N)			
MedullRecvSendComp (S)	MedullaRegulatoryCenter (N)	MedullaVasomotorReg (PS)		
		MedullaCardioReg (PS)		
		MedullaRespirReg (N)	InspiratoryCenter (PS)	
			ExpiratoryCenter (PS)	
			Pneumotaxic/IntegrationCenter (PS	
Manager (N)	**Federate (N)**			
	Federation (N)			

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy
Abdominal	ContractionLevel	double	1	percentage	hundredths	perfect
airMixture	perO2	float	1	percentage	tenths	perfect
	perN2	float	1	percentage	tenths	perfect
	perCO2	float	1	percentage	tenths	perfect
	altitude	float	1	m	nearest integer	perfect
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	TargetSystem	string	1	N/A	N/A	perfect
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	LocationXY	XYCoorData	1	N/A	N/A	N/A
Albuterol	Dosage	double	1	gm/ml	nearest integer	perfect
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	TargetSystem	string	1	N/A	N/A	perfect
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
Aorta	pO2In	double	1			perfect
	pCO2In	double	1			perfect
	FlowRate	double	1			perfect
	Diameter	double	1			perfect
AorticO2Recpt	Location	string	1			perfect
	pO2	double	1	mm Hg	thousandths	perfect
	Status	string	1			perfect
ArteryinBody	pO2In	double	1	mm Hg	tenths	perfect
	FlowRate	double	1		tenths	perfect
	Diameter	double	1	mm	tenths	perfect
	pCO2In	float	1	mm Hg	tenths	perfect
BAROAorticArch	Location	double	1			perfect
	Status	double	1			perfect
	BPChange	double	1	percentage	hundredths	perfect
	DirectionBPChange	string	1			perfect
BAROCarotidSinus	Location	string	1			perfect
	Status	string	1			perfect
	BPChange	double	1	percentage	thousandths	perfect
	DirectionBPChange	string	1			perfect
BodyEnvironMatrix	ExternalTemp	float	1	degrees Farenheit	integer value	perfect
	AirPressure	float	1	mm Hg	tenths	perfect
	Altitude	float	1	m	integer value	perfect
	LocationData	LocationXY	1	N/A	N/A	N/A
	Humidity	float	1	percentage	integer value	perfect
	AirComponents	AirConstituentPercent	1	N/A	N/A	N/A
	BodyAffectors	string	1+	N/A	N/A	perfect
Bone	BoneDamage	string	1			perfect
Bronchia	HOHDamage	string	1			perfect
	Diameter	float	1	mm	tenths	perfect

Appendix G - Attribute Table

Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable	Routing Space
perfect	Conditional	If changed	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
perfect	Periodic	Every cycle	TA	UR	N/A
perfect	Periodic	Every cycle	TA	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
perfect	Periodic	Every cycle	TA	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A
perfect	Periodic	Every cycle	TA	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	If changed	TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
N/A	Conditional	If changed	TA	UR	N/A
always	Conditional	Upon change	N	UR	N/A
N/A	Conditional	If changed	TA	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A

Appendix G - Attribute Table

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy
CardiovascularDuctwork	BVDamage	string	1			perfect
CarotO2Recpt	Location	string	1			perfect
	pO2	double	1	mm Hg	thousandths	perfect
	Status	string	1	N/A	N/A	perfect
CO	AmtCO	float	1	percentage	tenths	perfect
CO2	AmtCO2	float	1	percentage	tenths	perfect
Diaphragm	ContractionLevel	double	1	percentage	hundredths	perfect
Ear	EarDamage	string	1			perfect
Epiglottis	status	string	1	N/A	N/A	perfect
Esophagus	HOSDamage	string	1			perfect
ExpiratoryCenter	CycleTime	float	1	sec	tenths	perfect
ExternalIntercostals	ContractionLevel	float	1	percentage	tenths	perfect
Eye	EyeDamage	string	1			perfect
Federate	**FederateHost**	**string**	**1**			**perfect**
	FederateHandle	**string**	**1**			**perfect**
	FederateState	**string**	**1**			**perfect**
	FederateName	**string**	**1**			**perfect**
	RTIversion	**string**	**1**			**perfect**
	TimeManagerState	**string**	**1**			**perfect**
	FederateLookahead	**string**	**1**			**perfect**
	FederateTime	**string**	**1**			**perfect**
	TimeConstrained	**string**	**1**			**perfect**
	TimeRegulating	**string**	**1**			**perfect**
	FIFOlength	**string**	**1**			**perfect**
	TSOlength	**string**	**1**			**perfect**
	DequeueFIFOasync	**string**	**1**			**perfect**
	TotalObjectCount	**string**	**1**			**perfect**
	HoldingTokensObjectCount	**string**	**1**			**perfect**
	DeletedObjectCount	**string**	**1**			**perfect**
	NumAttributes	**string**	**1**			**perfect**
	NumParameters	**string**	**1**			**perfect**
Federation	**FederationName**	**string**	**1**			**perfect**
	FederationState	**string**	**1**			**perfect**
	FederatesInFederation	**string**	**1**			**perfect**
	SaveIsScheduled	**string**	**1**			**perfect**
	ScheduledSaveTime	**string**	**1**			**perfect**
	RTIversion	**string**	**1**			**perfect**
gas	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	TargetSystem	string	1	N/A	N/A	perfect
Heart	HeartRate	double	1	inverse time (per minute	hundredths	perfect
	StrokeVolume	double	1	ml	hundredths	perfect
	CardiacOutput	double	1	ml/min	hundredths	perfect

Appendix G - Attribute Table

Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable	Routing Space
perfect	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
perfect	Conditional	If changed	N	UR	N/A
perfect	Periodic		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Static		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Conditional	If changed	N	UR	N/A
perfect	Static		N	UR	N/A
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
always	**Conditional**		**N**	**UR**	**N/A**
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	If changed	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A

Appendix G - Attribute Table

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy
	PeripheralResistanceTotal	double	1			perfect
	ForceOfContraction	double	1		tenths	perfect
	BloodPressure	double	1	mm Hg	hundredths	perfect
HeartChambers	HeartChamberVolume	float	1	cm3	integer value	perfect
	EfficiencyofContraction	float	1	percentage	nearest integer	perfect
	pO2In	double	1	mm Hg	tenths	perfect
	pO2Out	double	1	mm Hg	tenths	perfect
	pCO2In	double	1	mm Hg	tenths	perfect
	pCO2Out	double	1	mm Hg	tenths	perfect
Chambers.HeartChambers	HeartChamberVolume	float	1	cm3	integer value	perfect
	EfficiencyofContraction	double	1	percentage	integer value	perfect
	pO2In	double	1	mm Hg	tenths	perfect
	pO2Out	double	1	mm Hg	tenths	perfect
	pCO2In	double	1	mm Hg	tenths	perfect
	pCO2Out	double	1	mm Hg	thousandths	perfect
HeartValves	Position	string	1	N/A	N/A	perfect
HollowSoftOrgans	HOSDamage	string	1			perfect
Human	HemoglobinBindingPercent	float	1	percentage	tenths	perfect
	Age	double	1			perfect
	Weight	double	1			perfect
	Temperature	float	1	degrees Farenheit	tenths	perfect
	HumanState	HumanStateData	1	N/A	N/A	N/A
	BloodLossRate	short	1			perfect
	SurvivalProb	unsigned short	1	percentage		perfect
	MaxAISCode	string	1			perfect
	ShuntFactor	double	1	percentage	tenths	perfect
InspiratoryCenter	CycleTime	float	1	sec	tenths	perfect
InternalIntercostals	ContractionLevel	double	1	percentage	hundredths	perfect
IrritantSensor	Location	string	1	N/A	N/A	perfect
	Status	string	1	N/A	N/A	perfect
Larynx	HOHDamage	string	1			perfect
	Diameter	float	1	mm	tenths	perfect
localChemicalVaporCloud	Concentration	float	1	mg/m^3	tenths	perfect
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	TargetSystem	string	1	N/A	N/A	perfect
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
localParticleClusterCloud	SizeofParticles	float	1	microns	nearest integer	perfect
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	IndentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	TargetSystem	string	1			perfect
LungConductingZone	AirwayResistance	double	1			perfect
LungRespiratoryZone	pO2staleBlood	double	1	mm Hg	hundredths	perfect

Appendix G - Attribute Table

Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable	Routing Space
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	If changed	TA	UR	N/A
always	Conditional	Every Cycle	N	UR	N/A
always	Conditional		N	UR	N/A
always	Conditional		N	UR	N/A
always	Conditional		N	UR	N/A
always	Conditional		N	UR	N/A
always	Conditional		N	UR	N/A
perfect	Conditional	Every Cycle	N	UR	N/A
perfect	Conditional		N	UR	N/A
perfect	Conditional		N	UR	N/A
perfect	Conditional		N	UR	N/A
perfect	Conditional		N	UR	N/A
perfect	Conditional		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
N/A	Conditional	If changed	N	UR	N/A
perfect	Conditional		N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Conditional		N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Conditional	If changed	N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Static		TA	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	If changed	TA	UR	N/A
always	Periodic	Every Cycle	N	UR	N/A

Appendix G - Attribute Table

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy
	pCO2staleBlood	double	1	mm Hg	hundredths	perfect
	pO2InspiredAir	double	1	mm Hg	hundredths	perfect
	pCO2InspiredAir	double	1	mm Hg	hundredths	perfect
	CO2DiffCoeff	double	1	ml/min/mm Hg	hundredths	perfect
	O2DiffCoeff	double	1	ml/min/mm Hg	hundredths	perfect
	pO2Out	double	1	mm Hg	tenths	perfect
	pCO2Out	double	1	mm Hg	tenths	perfect
	DMinverse	float	1			perfect
	MembraneSurfaceArea	float	1	cm2	tenths	perfect
	MembraneThickness	float	1	mm	integer value	perfect
	AveolarVentilationRate	double	1	L/min	tenths	perfect
Lungs	LungDamage	string	1			perfect
	LungVolume	double	1	cm3	tenths	perfect
	InternalLungPressure	double	1			perfect
	OverallAirwayResistance	double	1			perfect
	TidalVolume	double	1	ml	tenths	perfect
	DeadAirSpace	double	1	ml	tenths	perfect
	RespiratoryRate	double	1	inverse time (per minute	tenths	perfect
	LungCompliance	float	1	L/cm H2O	hundredths	perfect
	InspiratoryCapacity	float	1	ml	tenths	perfect
	VitalCapacity	float	1	ml	tenths	perfect
	TotalLungCapacity	float	1	ml	tenths	perfect
	InspiratoryReserveVolume	float	1	ml	tenths	perfect
	ExpiratoryReserveVolume	float	1	ml	tenths	perfect
	ResidualVolume	float	1	ml	tenths	perfect
MedulCO2Recpt	Location	string	1	N/A	N/A	perfect
	Status	string	1	N/A	N/A	perfect
	pCO2	float	1	mm Hg	tenths	perfect
MedullaCardioReg	status	string	1	N/A	N/A	perfect
	activityState	string	1	N/A	N/A	perfect
	BPHeartSysMonitor	string	1+	N/A	N/A	perfect
MedullaRespirReg	status	string	1	N/A	N/A	perfect
	activityState	any	1			perfect
MedullaVasomotorReg	status	string	1	N/A	N/A	perfect
	activityState	string	1	N/A	N/A	perfect
	BPMonitorTissues	string	1+	N/A	N/A	perfect
MedulPHRecpt	Location	string	1			perfect
	pHCerebroSpinalFluid	double	1		hundredths	perfect
	Status	string	1	N/A	N/A	perfect
Methacholine	Dosage	float	1	gm/ml	nearest integer	perfect
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	TargetSystem	string	1	N/A	N/A	perfect

Appendix G - Attribute Table

Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable	Routing Space
always	Periodic	Every cycle	TA	UR	N/A
always	Periodic	Every Cycle	TA	UR	N/A
always	Periodic	Every Cycle	TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Periodic	Every Cycle	TA	UR	N/A
always	Periodic	Every Cycle	TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Conditional	If changed	TA	UR	N/A
always	Periodic	Every Cycle	TA	UR	N/A
perfect	Static		N	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	If changed	TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Periodic	Every cycle	TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		TA	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	If changed	N	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	Upon change	TA	UR	N/A
always	Conditional	If changed	N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Conditional	Upon change	N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A

Appendix G - Attribute Table

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy
NasalCavity	NasalCavityVolume	double	1	cm3	integer value	perfect
	FlowRate	float	1	ml/min	integer value	perfect
NervousDuctwork	NerveDamage	string	1			perfect
	TransmissionFactor	double	1	N/A	hundredths	perfect
O2	AmtO2	float	1	percentage	tenths	perfect
OtherMiscOrg	OtherDamage	string	1			perfect
OtherSolidOrgan	SODamage	string	1			perfect
particleClusterCloud	LocationXY	XYCoorData	1	N/A	N/A	N/A
	LocationLL	LocationLLData	1	N/A	N/A	N/A
	ParticleSizeGroups	ParticleSizeGroupList	1	N/A	N/A	N/A
	Altitude	float	1	m	tenths	perfect
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	TargetSystem	string	1			perfect
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	Speed	float	1	km/sec	tenths	perfect
	DirectionofMotion	XYCoorData	1	N/A	N/A	N/A
Pharynx	HOHDamage	string	1			perfect
	Diameter	float	1	mm	tenths	perfect
PleuralCavity	PleuralCavityVolume	double	1	cm3	hundredths	perfect
Skin	SkinDamage	float	1	cm2	hundredths	perfect
smokeGasMixture	perCO2	float	1	percentage	tenths	perfect
	perO2	float	1	percentage	tenths	perfect
	perCO	float	1	percentage	tenths	perfect
	perOtherInert	float	1	percentage	tenths	perfect
	IndentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	TargetSystem	string	1	microns	N/A	perfect
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
SpinalColumn	CerebrospinalFluidPH	double	1		hundredths	perfect
ThoracicCavity	ThoracicCavityVolume	float	1	cm3	integer value	perfect
TissueGroups	MuscleDamage	string	1			perfect
	MetabolicRate	double	1			perfect
	pCO2Waste	double	1	mm Hg	hundredths	perfect
	pO2Demand	double	1	mm Hg	hundredths	perfect
	PeripheralResistance	double	1			perfect
	O2ExtractionCoefficient	double	1			perfect
	PercentCardiacOutput	float	1	percentage	tenths	perfect
	pO2ofTissueGrp	float	1	mm Hg	tenths	perfect
Trachea	HOHDamage	string	1			perfect
	Diameter	float	1	mm	tenths	perfect
VeininBody	FlowRate	double	1		tenths	perfect
	Diameter	double	1		tenths	perfect
	pO2Out	float	1	mm Hg	tenths	perfect

Appendix G - Attribute Table

Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable	Routing Space
always	Static		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Static		N	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A
N/A	Conditional	If sizes drop out;physics algorithm	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Conditional		N	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Static		TA	UR	N/A
always	Conditional	If changed	TA	UR	N/A
perfect	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A
always	Conditional	If changed	TA	UR	N/A
perfect	Static		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
always	Periodic	Every cycle	N	UR	N/A
always	Conditional	Every cycle	N	UR	N/A
always	Conditional	If changed	N	UR	N/A
always	Static		N	UR	N/A
always	Conditional	If changed	N	UR	N/A
always	Conditional	If changed	N	UR	N/A
perfect	Static		N	UR	N/A
perfect	Static		TA	UR	N/A
perfect	Conditional	If changed	TA	UR	N/A
perfect	Conditional	Upon change	TA	UR	N/A
perfect	Periodic	Every cycle	TA	UR	N/A

Appendix G - Attribute Table

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy
	pCO2Out	float	1	mm Hg	tenths	perfect
volatileChemicalVaporCloud	LocationXY	XYCoorData	1	N/A	N/A	N/A
	CloudDiameter	float	1	m	tenths	perfect
	Concentration	float	1	mg/m^3	tenths	perfect
	Altitude	float	1	m	tenths	perfect
	LocationLL	LocationLLData	1	N/A	N/A	N/A
	ImmediacyofEffect	ImmediacyofEffectDat	1	N/A	N/A	N/A
	PotLevelofInjury	GenericInjuryLevelInfo	1+	N/A	N/A	N/A
	TargetSystem	string	1	N/A	N/A	perfect
	IdentityProfile	IdentityProfileData	1	N/A	N/A	N/A
	Speed	float	1	km/sec	tenths	perfect
	DirectionofMotion	XYCoorData	1	N/A	N/A	N/A

Accuracy Condition	Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable	Routing Space
perfect	Periodic	Every cycle	TA	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A
N/A	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Static		N	UR	N/A
N/A	Static		N	UR	N/A
always	Conditional	upon "big enough" change	N	UR	N/A
N/A	Conditional	upon "big enough" change	N	UR	N/A

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